HANDBOOK

OF

Physical Medicine

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FOR PUBLICATION BY THE
COUNCIL ON PHYSICAL MEDICINE
AMERICAN MEDICAL ASSOCIATION

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were published under the title of
Handbook of Physical Therapy*

FIRST EDITION

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Handbook of Physical Medicine

INTRODUCTION

In order to keep pace with new developments in physical medicine, the fourth edition of the HANDBOOK OF PHYSICAL MEDICINE (formerly HANDBOOK OF PHYSICAL THERAPY [1]) has been prepared under the auspices of the Council on Physical Medicine (formerly Council on Physical Therapy) of the American Medical Association. Physical medicine in the opinion of the Council is a term employed to define the diagnosis and treatment of disease by various nonmedicinal means. Physical medicine includes the employment of the physical and other effective properties of light, heat, cold, water, electricity, massage, manipulation, exercise and mechanical devices for physical and occupational therapy in the diagnosis or treatment of disease. The reception which the profession has accorded to the previous three volumes is appreciated by the Council and the co-authors and amply repays them for the time and effort expended in the preparation of these volumes. The Council is gratified to note a far better understanding of physical medicine and a more intelligent application of physical therapeutic measures.

The HANDBOOK OF PHYSICAL MEDICINE is the outgrowth of twenty years of work by the Council on Physical Medicine of the American Medical Association. It represents a summary of the efforts of the Council during that period to separate the useful from the useless in this form of therapy, to evaluate the various physical therapeutic agents and the methods of their employment and to protect the medical profession, as far as possible, from the snares and pitfalls, both ancient and new, found in this field.

Dr. Joseph F. Smith of Wisconsin, realizing with many others of the profession the deplorable condition

then existing in 1925, brought a resolution before the House of Delegates of the American Medical Association in Atlantic City in May of that year, urging the Board of Trustees to establish a Council on Physical Therapy. The resolution was adopted and the Board of Trustees at its meeting the following September created the Council. After carefully studying the situation the Trustees chose nine men picked from the ranks of chemists, physicists, pathologists, physiologists, radiologists, and clinicians to compose the original Council. Later the membership was increased to twelve. In 1944. the Board of Trustees upon the suggestion of the Council, changed the name to Council on Physical Medicine.

The present membership of the Council on Physical Medicine is given on page 3. Other specialists having been members of the Council have either resigned, or their terms have expired, or they died in office. They are Dr. George C. Andrews, Dr. W. T. Bovie, Dr. W. B. Cannon, Dr. Arthur Compton, Dr. Richard B. Dillehunt, Dr. Frederick J. Gaenslen (deceased), Dr. Frank Granger (deceased), Dr. Yandell Henderson (deceased), Dr. Howard T. Karsner, Dr. George Miller MacKee, Dr. Harry E. Mock, Dr. Robert B. Osgood, Dr. Ralph Pemberton, Dr. A. S. Warthin (deceased), Dr. Francis Carter Wood.

Many members of the medical profession, representing the various specialties, have acted as referees or consultants for the Council. These men have tested physical agents and apparatus submitted for acceptance, studying the therapeutic claims made for them, evaluating the merit of special articles submitted for publication and aiding greatly in the educational work of the Council. The list of these referees and consultants is too long to be published here, but the Council wishes to express its appreciation for their services.

The Council on Physical Medicine during these twenty years of its existence has sought to become thoroughly familiar with the general aims, methods, and the scope of physical medicine and has endeavored to give the members of the profession the results of

this study. It has stimulated scientific investigation in physical medicine. Gradually, as the scope of its knowledge and function has increased, the Council has come to realize that its aims and purposes are threefold:

(a) To protect the medical profession and thereby the public against inefficient and possibly dangerous apparatus and against misleading and deceptive advertising in connection with the manufacture and sale of devices for physical therapy.

(b) To disseminate such reliable information as it possesses or may acquire and to stimulate instruction to aid the practicing physician in choosing true and sound physical therapeutic methods.

(c) To act in an advisory capacity to the profession and to the public in all matters concerning this branch of medicine.

In attempting to realize these aims, the work of the Council has progressed along two distinct but very closely allied lines: Firstly, the evaluation of the efficacy of physical therapeutic apparatus, usually but not always submitted for Council consideration, through a study of the therapeutic claims made for such devices; the elimination of false or misleading or exaggerated statements in advertising matter concerning the equipment and the publication of the Council's acceptance or rejection of the given physical agent in *The Journal of the American Medical Association.* A booklet "Apparatus Accepted," revised yearly, may be obtained free of charge by writing to the Secretary of the Council. Secondly, the improvement of the type of physical therapy practiced by the profession. To accomplish this the Council has aided in organizing both undergraduate and graduate instruction in medical schools; it furnishes speakers, films, slides and exhibits for many state, county and national medical societies and, finally, has supervised the preparation of many articles for publication in *The Journal of the American Medical Association.* Several of these articles are reproduced in the HANDBOOK. Slides are available for class room instruction, for hospital staff meetings, or for medical society meetings.

The purpose of the HANDBOOK will be served if it results in a closer union among general medicine, surgery and physical medicine for the cure and relief of suffering humanity. There have been three editions of the Handbook of Physical Therapy. This book would be the fourth edition were it not for the change of its name. It now becomes the first edition of the Handbook of Physical Medicine.

COUNCIL ON PHYSICAL MEDICINE.

EVALUATION OF METHODS USED IN PHYSICAL THERAPY

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In the final analysis, the success or failure of any form of therapy or therapeutic agent in human medicine is gaged by its action on living patients. The evaluation of the treatment is not to be measured by the opinions of the physician but rather by the facts he can demonstrate. It is often observed that any new form of treatment which may be suggested is regarded as valuable by groups of physicians and individual patients who try it. This means that psychic factors may mislead both physician and patient, unconsciously and involuntarily. Thus the benefit obtained is the result of psychotherapy rather than physical therapy. Although ability to manage the psyche should be in the armamentarium of all physicians, it is essential that the physician who studies the effects of drugs and of physical therapeutic agents must not be misled by psychic effects and must base his conclusions upon clearly established facts. It is our purpose to explain how the various devices and methods of physical therapy may be rationally evaluated. This evaluation must take into consideration the investigator, the matter to be investigated and the manner of the investigation.

The investigator is not merely a personality or a person. He must be one who by training, experience, initiative, imagination, controlled curiosity and intellectual honesty is qualified to undertake an objective examination of the matter in hand without preconceived ideas or prejudice. He must attack the problem calmly, deliberately, with a clear program based on a well conceived hypothesis, and be thoroughly familiar with the work of others along the same and similar lines. This plan excludes at once the charlatan. More important, it excludes those who commonly report on the value of a form of treatment or therapeutic agent without hav-

ing adequate knowledge of the method or substance employed, without supplying adequate proof of the accuracy of their diagnosis of the condition treated, and without affording a scientifically established demonstration of the value and accuracy of their conclusions by a comparison with control tests wisely chosen and properly performed.

In physical therapy it is not uncommon to find that the condition to be treated is not a well defined disease with established cause, characteristic course and clear cut pathologic alterations of form or function. When this is true, the biologic variations in manifestation are so wide that the investigation must cover an extremely large number of cases, both treated and controls, much greater than is necessary when the disturbance is in the form of a definite disease entity with a well established natural history and course.

For example, compare the treatment of some of the vague muscle and joint conditions showing no outward signs of disease, and pain the only symptom, with the treatment of a fracture similarly attended by pain. In the former case there is no objective way of determining improvement and it is difficult to know whether it is due to the physical or psychic effect of the treatment or simply a natural variation of the symptoms. In the latter case the changes following certain types of treatment can be determined objectively by various methods, and a better evaluation of the effects of the therapy can be made.

Physical therapy employs a variety of physical agents: massage, therapeutic exercise, water, air, radiations (heat, light, ultraviolet, x-rays, radium), vibrations (mechanical, sound) and electricity of various forms. All applied science is built on a groundwork of pure science, and in the same manner all the appliances of use in physical therapy have a background of knowledge in pure physics. Furthermore, rational therapeutics has at its call a certain volume of knowledge of the physiologic effects of the agents employed. Thus it is known that the physical agents just enumerated may cause certain physiologic and pathologic reactions.

The information available about these effects is much less than is true of a number of chemical substances used as drugs. For the furtherance of physical therapy it is necessary that a much larger bulk of concrete and

exact information be built up than is now available. These basic facts are to be furnished chiefly by the biologist, the physiologist, the biophysicist, the chemist and the pathologist. Funds can be well utilized in the enlargement of the field of knowledge by further intensive study, not only of the operation of various physical agents, but also in pursuit of information as to how and why they act. For example, it is known that, within certain ranges of wavelength, ultraviolet radiation activates substances in the living animal and in the test tube so that an active antirachitic material is formed. The exact process that takes place is not clearly established. Whether it is necessary for the rays to be used in such quantity as to cause erythema in order that this chemical or physical change may take place, and what part, if any, erythema does play in the process, are all problems. What effects these rays may have directly on cells and tissues, their form and their function, require further study. It is not known exactly how the activated ergosterol influences the metabolism of calcium and phosphorus to correct the changes incident to rickets. In the field of physical therapy it can only be said that ultraviolet rays prevent and cure rickets and favor the development of sound teeth and bones. Even this last phase is not incontrovertibly established; it is instead a strong presumption.

This general statement does not mean that ultraviolet rays may not have other beneficial effects nor that they have no potentialities of harm. It does mean, however, that precise information as to these other possibilities has not yet been obtained. The problems still to be solved in the fields of practice with these rays need further researches in the physics of the rays, the physiologic actions of the rays as well as the study of the rays in clinical practice. What has been said about the ultraviolet rays is applicable not only to the shorter rays of the spectrum (x-rays, grenz rays, radium) but also to the longer rays (visible, infra-red) of the spectrum. The problems are innumerable.

The physiologic effects of hydrotherapy are imperfectly known and this form of treatment, excellent though it be, is largely empirical and either entirely dependent on or intimately bound up with the effects of heat. The same is true of air. Our knowledge of the exact effects and mode of action of active

and passive motion, massage and rest is also incomplete. Fortunately most of the agents are neither harmful nor dangerous. Thus, provided the diagnosis be sufficiently well established so that there is no delay in any other treatment which may be necessary, many of these agents may be employed without risk to the human subjects of experimental investigations. In the case of some physical agents (e. g., ultraviolet rays) an indirect way of testing the effect on human beings or animals is possible. This is accomplished by the irradiation and activation of a substance (ergosterol), which is then administered. However, the latter in all likelihood does not act by giving off secondary ultraviolet rays to the body but more likely by means of other physical and chemical properties imparted by the rays to the previously inactive substance.

The study of the effects of physical therapy is of necessity largely, or partly, an experiment conducted on human beings. This experiment must be set up with all the deliberation and forethought of experiments in any line of scientific work. The evaluation of the effects of various physical agents in the treatment of certain skin diseases is not difficult, because it can be determined objectively. However, it is very difficult in the case of ill defined ailments which do not afford objective criteria for the determination of diagnosis and effect of treatment. As mentioned before, there is in human experimentation the psychic factor, which is of little and usually no significance in animal experiments. As Sollmann has said, such an experiment may utilize two methods, the first of which is the statistical and the second the comparative or blind test. In the statistical method, "alternate patients receive or do not receive the treatment." Owing to individual variations and psychic factors, this requires an extremely large number of observations.

In the comparative or blind test, one series of patients is treated with the agent under consideration and another is treated similarly but with inactive agents, masked in such a way as to be indisinguishable both by the patient and by the experimenter. In the case of drugs, this is easily effected. In the case of some forms of physical therapy it can also be accomplished. Thus, as regards ultraviolet radiation, for example, one series of patients might be treated with rays that are

unscreened or that have passed through permeable glass, and the other series with rays that have passed through glass impermeable to the ultraviolet portion of the spectrum. The blind test is often more desirable when direct treatment is being investigated. In the case of many physical agents, however, the masking of nonactive treatment and even any form of nonactive treatment is not possible. Yet, whenever practicable, it is, generally speaking, the more desirable method because it avoids favorably or unfavorably prejudiced opinions of the observer, whether those opinions are conscious or subconscious.

Owing to the limitations of this method in physical therapy, it will be necessary in many instances to fall back on the statistical method. Since this does permit of opinions on the part of the observers, the number of observations must be multiplied so as to decrease this particular factor of error. This error can be practically eliminated by objective evaluation of the effects without knowledge of the type of treatment used. Thus, one experimenter gives the treatment and another makes the observations on the patients without knowledge as to which have and which have not been treated. Strange to say, this critical part of the statistical method is rarely practiced in investigations on patients but is commonly used in experiments carried out on animals. It is the only method that is likely to lead to logical, sound and probably correct conclusions.

The main essential of any experiment in therapy is that observations with the particular form of treatment must be controlled and checked in a series of patients without the treatment. The number of observations must be so large as to minimize some of the disadvantages of random sampling. If the person who conducts the experiment is to know the nature of the method employed in each case, he must put personal opinions into the background and make his observations as objective as is humanly possible. Much can be learned from objective tests on animals, but the final test of the effects and value of all therapeutic measures designed for human beings is on the human patient and this is no less true of physical therapy than of drug therapy. The art of medicine is an essential superstructure built on the foundation of medical science, and neither the whole edifice nor any of its parts can have any escape from the inexorable laws of scientific evidence.

PHYSIOLOGIC EFFECTS OF HEAT

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The use of external heat in the sense ordinarily understood by that term was a familiar therapeutic procedure to the ancients of Greece and Rome, who constructed elaborate establishments for the practice of hydrotherapy in various forms and also made use of naturally occurring thermal springs, such as those still frequented at Aix les Bains. Notwithstanding the application of heat to an increasing variety of conditions, the manner in which it accomplishes its purpose has been, until recently, poorly understood, chiefly owing to the fact that the actual conduct of most physical therapeutic measures has been in the hands of persons untrained in medicine.

One of the outstanding phenomena, obvious even to the layman, in the systemic application of external heat is the more or less profuse sweat induced. This occurrence has given rise to the popular idea of "elimination," which has found great favor with the public and has even crept into medical writings in an uncritical way. The conception of what is eliminated has been vague, and small account has been taken of other and equally important changes induced. The last few years have been productive of new data however and, while much remains to be investigated, a fairly clear concept is now afforded of what occurs in the physiologic sense when the human body is exposed to heat.

According to Bazett,[1] radiant energy, to which the body is normally more or less exposed in the form of sunlight and also, in recent years, through artificial means, may be classed as (*a*) ultraviolet rays of short wavelength, 1,800 (artificial light), 2,900 (sunlight) to 3,900 angstroms; (*b*) visible light, from 3,900 to 7,600 angstroms; (*c*) near infra-red, from 7,600 to 15,000 angstroms; (*d*) intermediate infra-red, from 15,000 to

1. Bazett, H. C.: in Principles and Practice of Physical Therapy, Hagerstown, Md., W. F Prior Company, Inc., 1933, vol. 1, chapters 3 and 5.

30,000 angstroms, and (*e*) far infra-red with wavelengths greater than 30,000 angstroms. Heat from radiating objects, such as steam or hot water radiators, hot water bottles and hot water baths, consists mainly of group *e*, and transmission to a depth is by conduction; when derived from sources such as lamps with a dull red glow, the main energy is probably in groups *d* and *e*, and conduction is still the main method through which deep effects may be attained. However, if sunlight or luminous sources of heat are employed, much of the energy may be in groups *b* and *c* and some deep effects will result through direct transmission of the radiant energy to a depth.

According to Bazett,[2] the rate at which changes of temperature "penetrate" the tissues is relatively slow, the heat capacity of the tissues is high, and relatively large quantities of heat have to be "transported" before the temperature of the tissues is greatly altered. The tissues can be warmed, however, up to a temperature of 98.6 F. with relative rapidity; venous blood in its return carries heat inward and does so the more rapidly the greater the extent of the vasodilatation; in addition, the increased arterial blood supply warms the tissue at the expense of the rest of the body.

In a cold environment the conditions are simpler, but the thermal conductivity is diminished as the result of the vasoconstriction induced. Zondek[3] reported that an icebag in close apposition to the thigh caused a fall of temperature at a depth of 50 mm. from 98.8 to 97.3 F. in one hour when the skin had fallen to 44.6 F. in a subject with fat 25 mm. thick. In the case of a fat subject (fat 50 mm. thick) an icebag applied to the abdomen for one and one-half hours caused a fall of the skin temperature to 42.8 F., but the temperature of the abdominal muscles at a depth of 50 mm. fell only from 99.7 to 96.8 F.

In his study of the effects of abdominal thermal applications on the dog's intraperitoneal temperature, Brill[4] observes that cold applications have little effect on the intraperitoneal temperature, the greatest fall noted being 2.5 degrees C., which was observed in one instance. Hot applications likewise produce no appreciable change.

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2. Bazett, H. C.: in Principles and Practice of Physical Therapy, **1**: 7.
3. Zondek, cited by Bazett.[2]
4. Brill, Selling: Ann. Surg. **89**: 857 (June) 1929.

Such observations as these, which have been corroborated by Hepburn, Eberhard, Ricketts and Rieger,[5] strongly suggest that the beneficial effects of hot and cold abdominal applications are due to factors other than the effect on intraperitoneal temperature.

The effects of systemic exposure to heat from various sources are much the same in principle and will therefore be discussed together, except when certain differences necessitate particularization.

One of the earliest effects to be noted after systemic exposure to heat is that on the circulation. Thus, the pulse rate rises more or less proportionately to the rise in body temperature [6] in the ratio of about ten beats for 1 degree F.,[7] much as it does in fever.

The effects on blood pressure of external heat and cold are somewhat varied.[8] Some observers believe that all baths at a temperature much above or below that of the body raise blood pressure,[9] but in general in normal persons warm baths probably tend to lower blood pressure and cold baths tend to raise it. There are some exceptions to this rule, and a bath above 40 C. (104 F.) may give a blood pressure above normal, while a cold bath may occasionally induce a temporary fall in blood pressure preceded and followed by a rise.[7] If exposure to external heat is in the form of a bath, there takes place, in addition, a diuresis dependent on the immersion of the abdomen in the water.

Systemic exposure to external heat generally produces a more or less well marked hyperpnea or overventilation of the lungs. This increases roughly parallel with the rise in body temperature, and water vapor is lost in large quantities through the expired air. Systemic exposure to heat in any form results, therefore, in a loss of fluid from the body through the lungs and sweat and, following baths, through the urine also. This causes a temporary loss of weight.[7] Following extreme sweating a slight concentration of the blood [10]

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5. Hepburn, J. S.; Eberhard, H. M.; Ricketts, R., and Rieger, C. L. W.: Temperature of Gastro-Intestinal Tract, Arch. Int. Med. **52**: 603 (Oct.) 1933.

6. Adolph, E. F., and Fulton, W. B.: Am. J. Physiol. **67**: 573 (Feb.) 1924.

7. Bazett, H. C.: Am. J. Physiol. **70**: 412 (Oct.) 1924.

8. Pemberton, Ralph: Ann. Clin. Med. **5**: 763 (Feb.) 1927.

9. Hinsdale: Hydrotherapy, Philadelphia, W. B. Saunders Company, 1910. Bazett.[7]

10. Flinn, F. B.: Am. J. Physiol. **70**: 194 (Sept.) 1924. Gram: Proc. Soc. Exper. Biol. & Med. **21**: 137, 1932. Barbour, H. G.; Dawson, M. H., and Neuwirth, I.: Am. J. Physiol. **74**: 204 (Sept.) 1925.

tends to arise, but it is doubtful whether this takes place in any important degree under the usual conditions of clinical practice.[11]

Next to the kidneys the skin is, in man, the most important accessory channel for the elimination of water, and the salt excreted in the sweat may amount to ten times that normally present in the feces.[12] The sweat also contains, qualitatively, certain other substances occurring normally in the urine, such as urea, ammonia, uric acid, amino acids, creatinine, phosphates and sulphates,[10] and it may also contain dextrose. The elimination of these substances, especially water, salt and urea, forms the basis of the long-standing use of the sweat process in various forms of nephritis accompanied by edema or high blood urea nitrogen. There has been wide clinical belief in the value of this measure in nephritis, in which its influence is undoubted as regards salt and water. As regards the compensatory elimination of nitrogenous substances, there is some evidence to indicate it, but there are those who doubt "vicarious" excretion of nitrogen on the part of the sweat glands, and it seems that perspiration does not always lead to a decrease of urea in the urine.[13]

It is not generally appreciated that carbon dioxide, a chief end-product of metabolism, escapes through the urine and sweat, as well as through the lungs, and one of the most fundamental effects of exposure to heat appears to depend somewhat on the increased loss of carbon dioxide through these three channels. As a result of the rise in the body temperature or hyperpyrexia, the general body metabolism is increased and carbon dioxide is formed in quantities larger than normal. The overventilation through the lungs, however, washes out the carbon dioxide in even greater proportionate amounts. There also results from the heightened metabolism an increase in the phosphates and sulphates from the breakdown of protein, but these acid substances find their escape through the urine. In addition to the loss of all these substances, it has also been shown that the urine and the sweat contain fatty acids, including lactic acid, which are probably increased

11. Bazett.[7] Cajori, F. A.; Crouter, Caroline Y., and Pemberton, Ralph: J. Biol. Chem. **57**: 217 (Aug.) 1923.

12. Myers, in Barker: Endocrinology and Metabolism, New York, D. Appleton & Co. **3**: 512, 1922.

13. von Noorden, quoted by Matill, in Barker: Endocrinology and Metabolism **3**: 867, 1922.

in amounts during exposure to external heat. The elimination of lactic acid through the skin during the sweating process constitutes one of the significant factors in the maintenance of the acid-base equilibrium in the body. Because of the low degree of ionization of lactic acid, the excretion of lactic acid and lactates results in the sparing of fixed base.[14] The sweat produced under the influence of heat, induced by the radiotherm in the cases studied, contains lactic acid in concentration greater than that of the blood.

The net result, therefore, of the loss of these various acid substances, chiefly carbon dioxide, is to leave a relative excess of alkali in the blood and probably in the tissues.[15] The blood becomes too alkaline, a systemic alkalosis results, and the excess of alkali is then eliminated through the urine and sweat until the normal acid-base equilibrium is restored. The urine and sweat thus generally change their reaction, becoming less acid, alkaline, or more alkaline. A sustained alkalosis may lead to tetany; it constitutes one of the sources of danger in the improper therapeutic use of external heat.[16]

A great loss of water and salt consequent on exposure to heat induces serious consequences unless this loss is partly compensated by ingestion. This loss may be one of the factors, together with the alkalosis referred to, which induce the severe cramps in the muscles occasionally seen among stokers and other workers in extreme heat. The clinical application of external heat with excessive sweating may likewise be followed by serious consequences. Water is usually given to the patient, and saline solution is occasionally administered to compensate for the losses of fluid and salt. It is obvious however that, unless the temperature of the fluids ingested and also the amounts are considered, the anticipated sweating and the benefits of it may be prevented or delayed.

The physiologic changes induced by local exposure of a part to heat are along the lines just described, but more intensive treatment is obviously possible because

14. Fishberg, E. H., and Bierman, W.: J. Biol. Chem. **97**: 433 (Aug.) 1932.
15. Cajori, F. A.; Crouter, C. Y., and Pemberton, Ralph: The Alleged Rôle of Lactic Acid in Arthritis and Rheumatoid Conditions, Arch. Int. Med. **34**: 566 (Oct.) 1924.
16. Cajori, Crouter and Pemberton.[11]

the process can be longer continued before systemic consequences result. Relaxation of tissues is induced, especially of the muscles, together with a hyperemia probably due to dilatation of blood vessels and a greater total blood flow in the area concerned. Another physiologic factor involved is the increased rate of transfer of fluid across the capillary wall during the vasodilatation induced by heat, as shown by Gibbons and Landis.[17]

Local sweating also takes place, and the tissues are put in a condition to benefit more than they otherwise would by such measures as massage and passive motion or even active motion. If the local use of heat is continued too long, a systemic response may take place, dependent on a general hyperpyrexia comparable to that following systemic exposure. This may be an advantage or a disadvantage, according to the conditions present, but must be considered in feeble patients or those already being exposed to systemic heat. The effects of heat locally will be further developed under the local use of heat in surgery.

A recent development in the use of heat is the artificial induction of fever. A variety of measures is useful to this end; namely, those already mentioned and those depending on exposure of the body to radiation, to induced electric fields and to the actual passage of the electric current through the tissues. The measure last mentioned is that which has been most fully studied.

Another means of producing much the same result is the injection into the body of material such as killed bacterial organisms, foreign proteins and the like, the reaction to which includes the production of fever. It is probable that the results achieved by these several respective measures, however, depend largely on common factors for their effects. The use of hyperpyrexia through diathermy[18] permits rather more controlled study of the conditions arising and is in other ways preferable in a majority of cases suitable for such therapy. The alterations of physiology achieved through it include, apart from the usual results of external heat, the change in the blood formula recognized as accom-

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17. Gibbon, H. J., and Landis, E. M.: J. Clin. Investigation **11**: 1019 (Sept.) 1932.

18. Neymann, C. A., and Osborne, S. L.: Arch. Phys. Therap. **15**: 149 (March) 1934.

panying the use of nonspecific protein reactions, as well as some other phenomena referable to disturbances of the nervous system and even of the renal system brought about through the higher and more sustained febrile state. The kidney occasionally experiences detriment, under vigorous applications, and this may result, in part, from damage to it by the high temperatures immediately adjacent to the organ itself.

Observations conducted upon experimental animals throw light upon the nature of the physiological responses in fever therapy. In rabbits [19] fever per se destroys lymphocytic elements in proportion to the height and duration of the fever. Associated with this there is a marked infiltration of leucocytes into lymph nodes. There is also an increase in the polymorphonuclear neutrophils. Increases in the clasmatocytes are found in the lymph nodes, spleen and liver of animals subjected to the hypertherm, although these cellular changes are not noted in the circulating blood. The latter responses are more marked in those cases in which the fever is induced by malaria and by typhoid.

From a review of the literature and his own studies upon the physiological and pathological effects of fever induced by the Kettering hypertherm, Hartman [20] suggests that an anoxemia is an important feature. This view is based upon the fact that there is a decreased oxygen saturation of the arterial blood and a lowered oxygen content of the venous blood in experimental animals after fever therapy. Those animals which presented a saturation below 65 volumes per cent died. The factors leading to this state during hyperpyrexia include alkalosis, accelerated rate of blood flow, increased blood temperature and increased oxygen demand upon the part of the fixed tissues. The deleterious effect of these factors is enhanced in the brain because of the histotoxic action of the sedatives which are used coincidentally with fever therapy. The final pathological changes in the brain tissues are essentially similar to those produced by other anoxemic agencies such as asphyxia, carbon monoxide poisoning and acute

19. Doan, C. A.; Hargraves, M. M., and Kister, L.: The Differential Reactions of Bone Marrow, Connective Tissue and Lymph Nodes to Hyperpyrexia, Int. Conference on Fever Therapy, Simpson, M., and Bierman, W., New York, P. B. Hoeber, 1937.

20. Hartman, F. W.: Lesions of the Brain Following Fever Therapy: Etiology and Pathogenesis, J. A. M. A. **109:** 2116 (Dec. 25) 1937.

alcoholism. In the light of these observations the administration of oxygen throughout the period of fever therapy is indicated. Hartman further advises the use of a nasal catheter for the administration of oxygen inasmuch as this permits the ingestion of fluid, the application of ice to the face, and movements of the patient. The combination of carbon dioxide with oxygen may be used to counteract the alkalosis and apnea. These considerations further emphasize the importance of accessory hospital facilities in the use of therapeutic fever.

While the production of artificial fever unaccompanied by sweating does not produce changes in blood volume[21, 22] the induction of sweating with loss of water does lead to a reduction of the plasma volume. This loss of water from the blood must be replenished by entrance of fluid from the tissues or by fluids administered per os or parenterally. Rapidly induced lowering of plasma volume may lead to peripheral vascular collapse. This is one of the important complications arising from a prolonged period of sweating. It is evident that the loss of body water from the skin may be materially augmented by the circulation of relatively dry air over the skin surface. It appears to Gibson[21] and his associates that the principal changes associated with therapeutic fever are related to the severity of dehydration and to the extent of hyperventilation.

In addition to the necessity of replacing water losses, the importance of replenishing chloride deficits incidental to sweating has been emphasized by Warren[23] who noted that fever therapy was followed in seven cases by jaundice, accompanied by a low level of sodium chloride in the blood. Relief of this jaundice was not brought about by the administration of glucose but was achieved by the administration of sodium chloride. As an approximate dosage of sodium chloride during fever, it is recommended that 200 to 300 cc. of a 2 per cent solution be administered at a rate of 1 gram of sodium chloride per one hour period.

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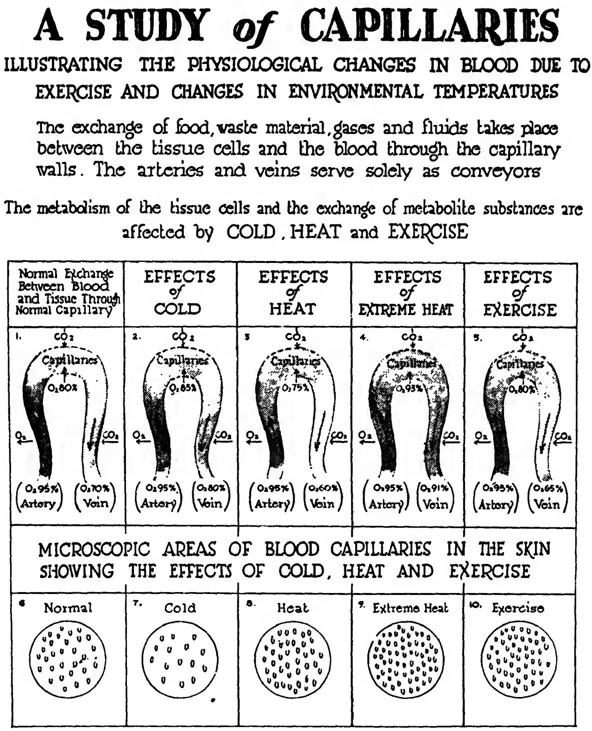
21. Gibson, J. G.; Kopp, I., and Evans, W. A.: Blood Volume Changes During Therapeutic Fever, Int. Conference on Fever Therapy, Simpson, M., and Bierman, W., New York, P. B. Hoeber, 1937, p. 30.
22. Gibson, J. G.; Kopp, I., and Pigoan, M.: Acid Base Balance During Therapeutic Fever, ibid. p. 33.
23. Warren, S.: Chloride Balance in Artificial Fever, ibid. p. 34.

Similar considerations apply to the use of ultra high frequency induced electric fields which cause eddy currents in tissues with resultant heating effects. This procedure permits of deep penetration and can be used locally or systemically. It has the added advantage of obviating immediate contact with the patient.



Brown, Dr. George, and Roth, Grace, Exhibit at A. M. A. Annual Session, 1933.
Goldschmidt, S., and Light, A.: Am. J. Physiol. **73**: 127, 146 (June) 1925.

The treatment of disease by means of hyperpyrexia originated with the use of the malarial parasite in dementia paralytica and has been extended to include a considerable variety of disease states. Omitting discussion of the therapeutic effects on diseases of the central nervous system, which will be considered elsewhere, the diseases chiefly submitted to this form of

Explanation of Capillary Study

1. Normal exchange between blood and tissue through normal capillary: One hundred cubic centimeters of blood saturated with oxygen contains 20.6 cc. of oxygen; that is, 20.6 volumes per cent. Arterial blood normally contains 95 per cent of this amount. Venous blood contains 70 per cent of this amount, while the concentration of oxygen in the capillary blood varies from 95 to 70 per cent of the saturated value. The saturation of oxygen depends on the rate of exchange between the tissue cells and the blood flowing through the capillaries.

2. During extreme cold the number of open capillaries is decreased, the rate of flow is diminished, and the metabolism of the tissues is inhibited. The rate of exchange between the blood in the capillary and the tissues is decreased; therefore the blood entering the vein contains about 75-80 per cent of its saturated value.

3. Between 18 and 39 C. (64.4 and 102.2 F.) temperature, the number of open capillaries is increased, the rate of flow through the capillary is increased, tissue metabolism is accelerated, and the rate of exchange between the blood and tissues is increased and reaches its optimum. The blood entering the vein contains from 60 to 65 per cent of its saturated value of oxygen.

4. Above 39 C. (102.2 F.) the number of open capillaries is greatly increased. The flow of blood is then so rapid that the blood entering the vein simulates arterial blood and contains about 91 per cent of its saturated value of oxygen.

5. During exercise, the number of open capillaries is greatly increased, the rate of flow of the blood is rapid, the exchange between the blood and tissues is accelerated, and optimal conditions are achieved. The blood entering the vein contains from 60 to 65 per cent of its saturated value of oxygen.

6. Under normal resting conditions there are from twenty-five to forty open capillaries in a microscopic field of one square millimeter of surface area of skin.

7. With cold the number of open capillaries is decreased, depending on the severity of the temperature. The rate of flow of blood through the capillary is diminished.

8. Heat increases the number of open capillaries and the rate of flow through the loops.

9. With extreme heat the maximal number of capillaries is open and the rate of flow is markedly increased.

10. During exercise the number of open capillaries is greatly increased, but the flow is not as greatly increased as during extreme heat.

therapy have been various forms of arthritis and asthma.

The treatment of disease states by raising the body temperature through various electrical means is a powerful therapeutic measure capable of real benefit and also of undoubted harm unless carefully controlled. At the present time, therapy of this nature should be conducted under hospital auspices.

FORMS OF APPLICATION

Dry Heat.—The various means and methods of applying physical therapy in almost any of its forms constitute specialties in themselves, and within the small compass of the present article only those features can be considered which are essential to a general understanding of the subject.

Apart from the familiar hot water bag, the most common mode of application of dry heat is that afforded by the electric light bulb. For local application, the apparatus usually takes the form of a parabolic mirror, suitably mounted, with the lamp at the focus so that the issuing rays are parallel. The apparatus can be held in the hand, or it is mounted on a stand and can be directed toward any part. For more intensive local use a boxlike container, with or without an internal reflecting surface, open at the ends and equipped with light bulbs, is placed over the limb or part, with the patient in the sitting or the reclining position.

For systemic exposure, lamps are usually placed within a "cabinet" or large box containing a reflecting interior surface and large enough to allow the subject to sit on a chair, the head emerging through the doors or other covering at the top. The number of lamps in such an apparatus may be from twenty to fifty or more, subject to control in small groups. For exposure in the recumbent position, the lamps are placed within a troughlike semicircular container, also bearing a reflecting interior surface and about 5 feet in length. This is placed, with the concave side down, over the subject, whose head is allowed to emerge at one end. Blankets are placed over the whole and drawn snugly around the neck and face in order to prevent undue radiation.

Dry heat is also administered in the form of hot air, but this usually requires elaborate equipment for the purpose of heating the air and is hardly available to

the general practitioner, except in a few institutions. Electrical resistance coils placed within a boxlike container also afford a useful means of obtaining dry heat, especially for application to limited areas such as a knee or an ankle. These various forms of apparatus can all be obtained on the market under various trade names, and they can be improvised at home with excellent results when necessity demands. Dry heat of lesser intensity can also be supplied for local purposes in the form of a resistance coil of flexible wires, properly insulated and covered with cloth, for such uses as those to which the familiar hot water bag is put.

One of the most important uses of dry heat in a local sense is that afforded by the actual cautery, which may be heated by flame or fire, as in the old days, or, more appropriately, by the electric current. The chief use of this is for destructive purposes, as in dermatologic conditions, including new growths, and will be discussed under that heading. "Electric desiccation," so-called, has come into a wide variety of uses. The actual cautery has also long been used as a "counterirritant" in sciatica, though less so now than formerly. Probably some of its effects are due to the reaction from protein split products and the "shock" of the burn.

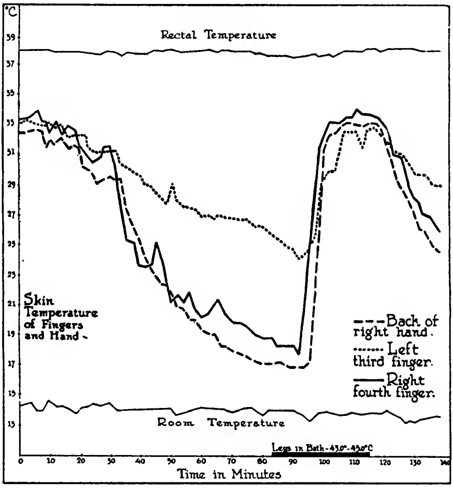
Hydrotherapy.—Probably the oldest form of the systemic application of heat is the hot bath. The presence of thermal springs scattered throughout the world has given rise to elaborate establishments for their utilization, but as far as heat per se is concerned almost equally satisfactory results can be obtained in many instances by the simplest forms of apparatus, such as the ordinary bath tub. The water used may be pure or it may contain various salts or other substances, such as magnesium sulphate or carbon dioxide, intended to increase or add to the effects. The temperature of the water varies, of course, according to the purpose of the bath, and this question will be considered under therapeutic indications.

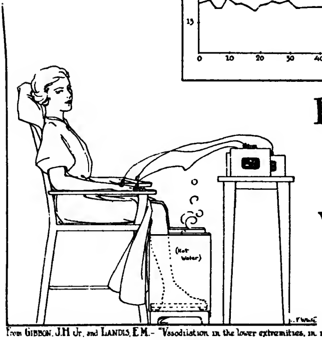
Next to the hot bath, the most frequently employed form of moist heat is that afforded by the so-called hot pack. This consists in principle in wrapping the body in a sheet or blanket made hot by being dipped in hot water of about 82 C. (180 F.) and subsequently wrung out more or less thoroughly. Obviously the severity of application will depend on the temperature of the envel-

VASODILATION IN THE HANDS

PRODUCED BY IMMERSING THE FEET AND LEGS IN WARM WATER

Skin temperature depends on rate of blood flow... Low skin temperature indicates diminished blood flow —— high skin temperature, increased blood flow..



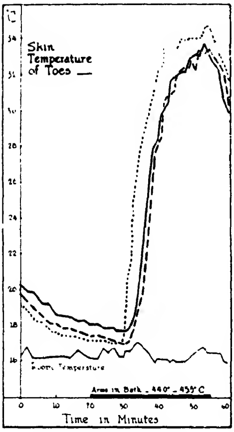


IMMERSING THE FEET FOR 35 MINUTES IN WARM WATER (43° to 45°) INCREASES RATE OF BLOOD FLOW IN THE HANDS BY DIMINISHING VASOCONSTRICTOR TONE IN THE UPPER EXTREMITIES. VASODILATION THUS PRODUCED IS ALMOST AS COMPLETE AS THAT RESULTING FROM SYMPATHETIC GANGLIONECTOMY, BUT PERSISTS ONLY AS LONG AS PATIENT FEELS WARM.

From GIBBON, J.H. Jr. and LANDIS, E.M. - "Vasodilation in the lower extremities, in response to immersing the forearms in warm water." 1932 - Journ. of Clin. Invest. - XI - 1019

VASODILATION IN THE FEET

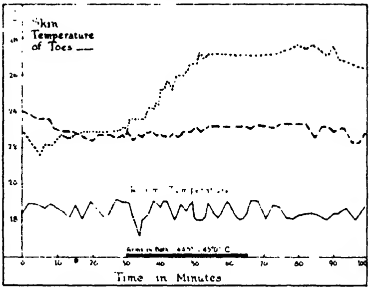
PRODUCED BY IMMERSING THE HANDS AND THE FOREARMS IN WARM WATER.



NORMAL SUBJECT

.... Left first toe
- - - Right first toe
—— Right second toe

Complete normal response.

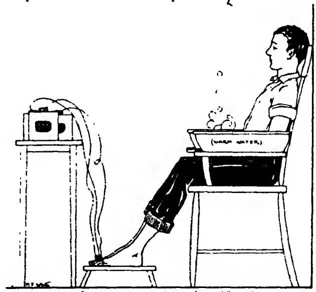


PATIENT WITH ARTERIOSCLEROSIS

.... Left first toe. moderate organic arterial disease
- - - Right first toe marked organic arterial disease

If the blood vessels are organically diseased, they can no longer dilate normally and the rise in temperature will be partial or completely absent.

IMMERSING THE FOREARMS FOR 35 MINUTES IN WARM WATER NORMALLY PRODUCES VASODILATION IN THE VESSELS OF THE LOWER EXTREMITIES, AND THE SKIN TEMPERATURE OF THE TOES RISES TO 31.5°C. OR MORE.



From Gibbon J.H. Jr and Landis E.M. "Vasodilation in the lower extremities in response to immersing the forearms in warm water." 1932 Journal of Clinical Investigation II 1019

oping sheet or blanket, and this effect will be further influenced by the number of blankets superimposed on the subject to prevent evaporation and cooling. Occasionally, the sheet or blanket placed on the body is below body temperature, constituting the "cold pack," under which circumstances the effect of heat is achieved through a conservation of the body heat by wrapping the subject with many blankets to prevent as much evaporation as possible.

Another form of exposure to moist heat is the steam bath, although this is by no means so widely employed as the hot water bath. A home-made apparatus can usually be "rigged up" in any household by means of large steam kettles, an oil lamp and a frame to elevate the bedclothes. The steam "room" has long been in use and consists simply of a chamber into which steam under low pressure is allowed to escape. The disadvantage here is that the patient must breathe the hot moist air, and a better form of application is that in which the subject sits in a cabinet or lies in a sort of box with his head outside. There is some danger, however, in this procedure, as burns have occasionally been caused by faulty steam pipes or joints. In some instances, electric resistance coils supply steam under low pressure in a manner well adapted to this purpose.

The mud bath is an old form of application of moist heat but, in general, depends on the availability of certain soils, heated by thermal springs or artificially, and need hardly be considered at length here.

The forms of wet heat that have been described are used chiefly for systemic treatment, but a useful local application of moist heat can be made by means of the so-called whirlpool bath. This consists of a receptacle of suitable shape, usually deep and rather narrow, containing warm or hot water made to circulate rapidly by means of a laterally placed water jet. The part to be treated, usually an arm or a leg, is placed within the receptacle, and the temperature of the water is gradually raised to the desired point. The motion of the water intensifies the effect of the heat for any given temperature and has other advantages through its impingement on the tissues.

THERAPEUTIC INDICATIONS AND PRACTICE

The therapeutic indications for the use of external heat can be grouped under the two general headings of general exposure and local exposure, according to whether a systemic or a local effect is desired. Systemic effects find their application for the most part in medical, as contrasted with surgical, conditions and have been widely used in the following disease states or syndromes: nephritis, acute or chronic; arthritis and rheumatoid conditions, in which either local or systemic heat or both may be used; and neurologic conditions, including neurasthenia, functional psychic disturbances and the true insanities.

The therapeutic indications for the use of heat locally are chiefly in the following fields: surgery, especially orthopedic, following fractures, dislocations, sprains, cicatrization after operative procedures and the like; arthritis, when a limited influence on a joint or joints is desired; associated conditions such as myositis, neuritis and fibrositis; and circulatory disturbances of the extremities.

NEPHRITIS

There is probably no other condition in medicine in which the systemic use of external heat has been longer thought to have consequences of value than that of nephritis. Whatever other pathologic manifestations may accompany nephritis, certain symptoms demanding treatment are apparently dependent on the retention of toxic material, possibly of a nitrogenous nature, salt or water, and acid products of metabolism, especially phosphates and sulphates.

As already pointed out, some workers doubt the vicarious removal of nitrogenous substances through the skin, when elimination through the urine is reduced, but clinical experience is in favor of the view that something of this nature may occur. Furthermore, it is possible that some other toxic substances the nature of which is not yet known may be removed at the same time. It is well recognized, however, that the degree of toxicity does not run precisely parallel with the accumulation of nitrogenous substances. Thus, patients with uremia may show a disproportionately small rise in the blood urea nitrogen and, on the other hand, patients with marked increase in the blood urea nitro-

gen may present few or no clinical evidences of intoxication. Again, the figures for the "urea clearance" test may fall as low as 20 to 40 per cent in the presence of a normal blood urea.[24] It is safe to say, however, that in nephritic conditions accompanied by marked laboratory evidences of retention of nitrogen, or by clinical evidences which suggest the toxemia consequent on such retention, the sweating process is to be considered. There is some evidence that in conditions accompanied by retention of blood nitrogen the sweat may contain nitrogen in amounts larger than normal.[25]

The argument has been advanced that, in the presence of toxemia from renal insufficiency and retained nitrogen, sweating serves only to concentrate the blood and to add to the danger from the retained substances.[26] There is some doubt as to the validity of this, however, as the blood maintains its water balance with great tenacity, drawing on the tissues for this purpose, and the evidence is not final that under conditions of ordinary therapeutic procedure the blood undergoes any true concentration.[8] Furthermore, in the absence of inability to excrete water there would seem to be no objection to the administration of fluid to prevent concentration, as is indeed the practice in many hospitals. It is to be borne in mind, however, that the elimination of water constitutes one of the functions of the kidney, and, as O'Hare [27] points out, a further burden may be added and even pulmonary edema may arise from undue administration of fluids.

Finally, it should be stated that the results believed to be achieved may be due to changes induced by heat in the blood flow, to an alteration of metabolism, or, in nephritis accompanied by acidosis, to the production of a systemic alkalosis as already described. Whatever the mechanism and whatever the difference of opinion as to the theoretical benefits to be obtained, however, it is probable that some experienced clinicians would be unwilling to withhold application of the sweat process as a practical method of treatment in the toxic nephritis under discussion.

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24. Beaumont, G. E., and Dodds, E. C.: Recent Advances in Medicine, Philadelphia, P. Blakiston's Son & Company, 1934, p. 49.
25. Cajori, Crouter and Pemberton: Ann. Int. Med. **2**: 1243 (June) 1929.
26. Foster, Nellis, B.; Cecil, R. L., and Kennedy: In Textbook of Medicine, Philadelphia, W. B. Saunders Company, 1930, p. 926.
27. O'Hare, J. P.: The Treatment of Chronic Bright's Disease, J. A. M. A. **103**: 1373 (Nov. 3) 1934.

Another phase of renal dysfunction in which the sweat process has long been regarded as of value is that accompanied chiefly by retention of salt and water. While the bowels may be made the channel for elimination of water in large quantities by hydragogue cathartics, water can be eliminated in equal or even greater amounts through the sweat. Evidence has been presented that salt may be removed through the sweat channels in amounts equal to or larger than those occurring in the feces.

In the presence of edema or anasarca of renal origin, the hot pack or general body bake may at times have significant consequences and the loss of fluid from the tissues may be obvious almost from the start. Usually, however, many treatments are required.

The practice of giving sweat baths in nephritis is less common than formerly. The modern view of therapy in chronic Bright's disease is directed toward the elimination of toxins which, in passing through the kidney, may aggravate the renal lesion. This means the eradication of infection, proper elimination from the bowel, and finally a diet so devised as to avoid undue strain on the renal system by all products of excretion. This, of course, may include the ingestion of water. It would appear that proper adjuvant use of the sweat channels would be complementary to the foregoing procedures, but the problem is fraught with many difficulties that have not been wholly threshed out.

In all these conditions the physician must be guided by good judgment in the application and severity of the measures used. The guiding principle must be that benefit can be forthcoming only when the patient is in a position to withstand treatment of such severity and respond to it, and the physician must be on his guard lest contraindications appear, such as cardiac decompensation, circulatory collapse or high fever.

The particular manner in which heat is systemically applied in nephritis is of secondary importance; but the simplest form, and one that can be carried out in any household, is the hot pack already briefly mentioned. This properly comes under the topic of hydrotherapy, however, and the further details of its application will be discussed there.

Considerable prostration may occasionally follow the aforementioned general procedure; and, furthermore, although the effect of any one "bake" may be inappreciable, the effect of many treatments is sometimes cumulative. In few diseases is any single measure to be regarded as the only one to be relied on, and this is eminently true of the use of the sweat process in nephritis. The use of the skin as an emunctory organ must be accompanied by full use of the other channels, especially the bowels, and by such medication and control of protein, salt and fluid intake as modern conceptions of medicine require.

The systemic application of heat is beneficial in meeting the conditions generally included under the head of shock. In this connection mention should perhaps also be made of the use of the mustard bath or the mustard pack, especially in relation to collapse in infants. Some clinicians [28] believe that there is no medicinal agent, with the exception of epinephrine, which is so dependable. The water should approximate 105 F., and mustard should be added in the amount of a heaping tablespoonful to each quart of water. Care must be exercised to protect the eyes of the patient, and constant friction should be maintained while the subject is in the tub. Baths of this general nature are useful also in relation to the convulsions which children experience, but this subject properly belongs under the use of heat in diseases of the nervous system.

Heat in the form of hydrotherapy has long constituted part of the process known under the name of the Nauheim bath, extensively used at Nauheim, Germany, in relation to cardiac disorders of various kinds. The temperature of the water begins at 92 F., and the measure in general can therefore be properly placed in the category of systemic heat. The benefit to be derived by the Nauheim bath is a matter over which there is much difference of opinion. The beneficial consequences alleged to arise have been referred to the carbon dioxide content of the water and also to the friction employed while the subject is in the bath, as well as to various other factors, such as rest and change of scene.

Part of the benefit almost surely depends upon the stimulation afforded to the capillary beds of the skin, muscles and superficial tissues. About 25 per cent of

28. Ward, J. B.: Arch. Pediat **45**: 556 (Sept.) 1928.

the blood is contained in the capillary beds as a whole and it is probable that until very recently inadequate attention has been paid to this aspect of the circulatory dynamics, at least from the standpoint of clinical medicine.

It must be confessed that the favorable clinical evidence adduced by those who have the greatest familiarity with the "Nauheim bath" is considerable, and it is also only fair to say that the conditions which obtain at Nauheim cannot necessarily be duplicated elsewhere through the use of artificial baths of the same general nature.

This form of treatment has never had very wide use in the United States, and it would profit by further study at the hands of disinterested observers.

ARTHRITIS AND RHEUMATOID CONDITIONS

The field in which the application of external heat, both systemically and locally, has its most extensive and varied application is probably that of arthritis and rheumatoid conditions. The full benefits to be derived from the systemic use of heat in this connection are not always forthcoming from the heat alone, however, and sometimes depend on contrasting and accessory applications of cold. The latter phase of treatment constitutes an essential part of hydrotherapy, and the details of the conduction of this measure in its various forms will be considered in the section devoted to that topic. The matter will be discussed here sufficiently merely to indicate the general application of heat to the rheumatoid syndrome.

In view of the considerable confusion that still exists regarding the nomenclature and classification of the arthritides, as well as of the underlying pathologic changes concerned, there is no stereotyped guide to be followed in selecting cases appropriate for exposure to systemic heat.

Those patients who are fairly robust afford the best opportunity for this practice. It is important to remember that systemic exposure to heat in any form may occasionally have distressing consequences, either immediately or after a course of treatment, and it is therefore essential to exercise caution in subjecting to such treatment patients who are ill equipped to stand it. Those forms of arthritis which are thought per-

haps to withstand such therapy best and to benefit most from it are cases of the degenerative or so-called hypertrophic type in middle aged, well nourished women, although the proliferative or so-called atrophic type may be equally helped. It must be pointed out here, as in connection with nephritis, that exposure to heat or hydrotherapy constitutes only one measure of treatment in the rheumatoid problem and must not be followed except in correlation with other established principles of therapy. Especially is this true in relation to the important influence of focal infection. A patient with arthritis should not be subjected to the measure under discussion unless and until a complete medical examination has indicated the justifications and indications for it. For generations the public has frequented sanatoriums of all kinds where these measures have been applied in a wholesale way with the result that, although these measures have undoubted therapeutic value, failure and detriment also have followed.

As mentioned in the section on physiology, belief in the value of "elimination" in this disease has long been popular, but there is only limited evidence to support this as an important factor in itself. Elimination of water [29] in the form of sweat may in itself contribute to a betterment of the disturbances of physiology accompanying the rheumatoid state. The fact that a low-grade "edema" of at least the peripheral tissues accompanies certain phases of the arthritic syndrome should have more consideration than it has yet received. It seems probable that this edema constitutes part of the actual "pathology" characterizing the syndrome at least so far as the stiffness and, in part, the pain are concerned. There is, however, definite evidence that some of the other effects achieved by exposure to heat play an important role in the treatment of arthritis. These effects are chiefly those arising from the heightened circulation and the increased metabolism induced. Evidence of changes in the circulation is to be seen in the obvious influence on the skin capillaries of the contrast baths or douches so successfully used in institutional treatment at the conclusion of the "bake" or hot bath. A true "metabolic whip" is afforded by cold water properly used.

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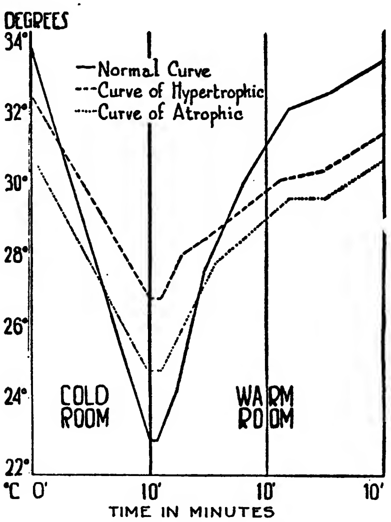
29. Pemberton, Ralph, and Scull, C. W.: M. Record **140**: 653 (Dec. 19) 1934.

This procedure has application to a variety of debilitating conditions; thus, Knopf in his "Report to the United States Government on Tuberculosis with Some Therapeutic and Prophylactic Suggestions," expresses the opinion that a judicious course of hydrotherapy is of value in helping to "strengthen the cutaneous and nervous systems against the changes of temperature" and has prophylactic value toward the development of "colds" among certain classes of tuberculous patients.



Fall of surface temperature of normal persons and of arthritics after exposure in cold room. Note slower fall of arthritics and slower rise after return to warm room. Arthritics show lowered surface temperature because of closure of capillaries. They react sluggishly to environmental changes.

The "bake" or bath may be given alone, however, in which case profuse sweating is induced and the subject is allowed to rest for an hour or more to compensate for the somewhat debilitating effects; or, more frequently, the exposure to heat is briefer and sufficient only to inaugurate or induce a mild diaphoresis. Following this procedure, which is generally administered with the patient in a sitting posture, a "tonic" shower or douche is given, beginning considerably above body temperature and shortly reduced to slightly below body temperature. This is best accomplished by an attendant

who directs on the patient a jet of water, the temperature of which is under control. An exposure of about eight minutes to the electric cabinet "bake," followed by a so-called scotch douche or other form of cooling hydrotherapy, permits the subject to go at once out into the air with a sensation of exhilaration and well being instead of lassitude. There is also exercised at the same time an influence on the nervous system, which in the end may be quieted by the process described, notwithstanding the apparent "shock" of the cool or cold water. Even persons of robust constitution should be subjected only gradually to these procedures; but by beginning cautiously even highly asthenic types can be educated to stand them and be benefited by them.

The sweating process alone, without the cooling contrast shower, is easier of attainment and can be brought about by means of the hot pack or hot bath in almost any household. In many instances the metabolic stimulus given by this single procedure is of great value and should be utilized when circumstances justify it. Some of the effects of cooling hydrotherapy can be achieved by means of the bed sponge or bath, but care must be used to avoid chilling. If the sweating process is prolonged and perspiration is profuse, the patient must rest for an hour or more before arising, or depletion and fatigue will result.

The general regimen briefly outlined can be carried out more or less successfully in the home, but the full achievement there of such results as follow the conduction of these measures by skilled hands in adequately equipped institutions can hardly be expected.

Much of the benefit of treatment at institutions is made possible by the incidental removal of the patient from causes of worry and fatigue, and to this can often be added the stimulus of new surroundings.

Some further mention must be made of the influence of induced fever,[30] probably most conveniently achieved in the rheumatoid syndrome through diathermy. There is only limited evidence that it is of much value except in a true gonorrheal arthritis where it may achieve brilliant results because of the low thermal death point of the gonococcus. The whole subject of the influence of induced fever on various disease states is still far

30. Jones, A. C.: Arch. Phys. Therap. **15**: 149 (March) 1934.

from being thoroughly understood, and this limitation applies equally in respect to the treatment of chronic arthritis of the kind here under discussion. There is some evidence to indicate, however, that in certain phases of the arthritic syndrome, especially perhaps the more acute and early stages of atrophic arthritis, beneficial results may follow the induction of sustained fever up to 104 or even 106 F. Differing uses of nomenclature as well as uncertainty as to diagnosis make it difficult to attach finality to the value of the beneficial results reported to date. In view of the varied etiology of arthritis, conservatism should be exercised in applying this potent measure indiscriminately to large groups of cases, in that many of them are asthenic and poor candidates for radicalism of any sort. Furthermore, the induction of hyperpyrexia by means now under consideration is a purely institutional measure and should never be resorted to except under fully controlled conditions and in experienced hands.

This view is essentially similar to that presented by Hench,[31] et al., who observe that the administration of therapeutic fever requires as much care as is necessary for surgical operation. The use of this measure in gonococcal arthritis is regarded as indicated, in chorea as justifiable, but disappointing in atrophic arthritis and not indicated in hypertrophic arthritis.

LOCAL APPLICATION OF HEAT IN ARTHRITIS

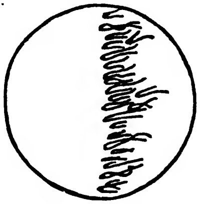
The application of external heat locally to a joint or joints in arthritis is often of the highest value. The principle obtains here, as elsewhere, that reliance must not be placed on this measure alone. It must be considered in conjunction with other principles of treatment of the disease as a whole and the joint in particular. The measure most often employed in conjunction with local external heat in arthritis is massage and, although often misused in ignorant hands, it constitutes an almost necessary adjunct to the use of heat alone, especially in the form of effleurage. The forms of heat available for local use are discussed at the beginning of this article. The value of the heat can sometimes be enhanced by incorporating with it some other principle, as in the use of a hot saturated solution of magnesium

31. Hench, P. S., and others: The Present Status of Rheumatism and Arthritis. Ann. Int. Med. 11: 1089, 1938

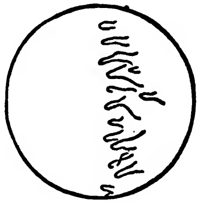
sulphate applied to the affected part and kept hot by repeated application or a radiant lamp. This procedure sometimes greatly relieves pain. Application of heat should not be carried to the point of irritation and should depend for its effects on repeated use, once or twice a day, over a period varying from about ten minutes to half an hour. In cases of hypertrophic arthritis, heat

CAPILLARIES AT BASE OF NAIL UNDER MICROSCOPE

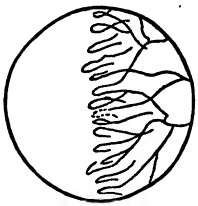
Normal Capillaries



Capillaries of Arthritics



Capillaries of Arthritics After Heat and General Massage



may act as a form of trauma, in the sense elsewhere discussed,[32] and greatly aggravate the existing condition. The temperature within the apparatus should not be above about 82 C. (180 F.), or the duration of treatment greater than twenty minutes at the outset. Temperature and length of exposure can be slowly increased. Local sweating generally occurs, and the part should be kept warm after the treatment. If a

32. Pemberton, Ralph: The Use of Massage in Internal Medicine, this Handbook.

region such as the shoulder is baked for a long period, a systemic reaction may occur comparable to that following systemic exposure, the results of which may be depleting or otherwise undesirable.

Heat is of value also in disturbances of circulation in the peripheral vessels, such as thrombo-angiitis obliterans, diabetic gangrene, Raynaud's disease and intermittent claudication. Heat has been recommended systemically [33] in thrombo-angiitis obliterans to control pain but can be more conservatively used locally.

In advanced peripheral vascular diseases, Starr [34] recommends heat at an "optimal temperature" in conjunction with rest, desiccation and exposure of the part to oxygen. A temperature of from 33 to 35 C. usually relieves pain and is preferable to less controlled variations.

There may also accrue a beneficial effect on the indolent lesions often encountered in such conditions. Coincident care of the underlying state is of course imperative. Contrast baths may have value when the local vascular function permits.[35]

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33. Stroud, W. D.: Year Book of General Medicine, 1934, p. 628.
34. Starr, Isaac, Jr.: Am. J. M. Sc. **187**: 498 (April) 1934.
35. Perlow, Samuel: Ann. Int. Med. **8**: 743 (Dec.) 1934.

HEAT IN SURGICAL AND ORTHOPEDIC CONDITIONS

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The use of heat in the treatment of disease and injuries is one of the oldest forms of therapy known to man.

The abuse of heat is a common practice, and there are altogether too many who think that disease can be cured by "cooking." There are also far too many patients being "cooked" because the physician when unable to make a diagnosis prescribes the now popular short wave diathermy treatment, hoping to cure some obscure lesion as a face saving measure. It would seem, then, that there should be some experimental evidence to show when heat is indicated or contraindicated, how often, how long and where it should be applied and, finally, when it ceases to be of value. It must be remembered that there are persons who do not tolerate heat at all; in fact, heat may make them more uncomfortable.

LOCAL HEAT

Locally heat is used in the form of poultices, hot water packs, hot water bottles, electric pads, special electric lamps, arranged singly or in multiples, chemical pads, paraffin baths, short wave diathermy and diathermy.

There are some dangers in the use of local heat. Inflammation and congestion may be increased, and severe burns are not uncommon. The physician may be sued if a patient is burned when heat has been applied by the physician or by an attendant carrying out the physician's orders.

GENERAL HEAT

General heat is used in the form of hot water baths, steam baths, vapor baths, dry thermal cabinets and electric blankets.

There are also dangers in the use of general heat. Thermal cabinets or vapor baths should not be pre-

scribed without safeguards: the patient must be physically able to stand this sort of heat. The temperature should not be beyond the danger point, and the heat should be used only by those who have had experience in its use. Above all, trained attendants must be present at all times.

The objects of heat are to relieve pain, swelling and spasm. It stimulates the circulation, thus permitting the waste products of inflammation to be carried off into the system. Heat should be considered an adjunct to rest, massage and active exercise. It alone does not restore physiologic use of a joint or muscle.

SPECIAL CONSIDERATION

The use of heat is indicated in contusions, strains, sprains, dislocations, fractures, synovitis (except tuberculosis), bursitis, tenosynovitis, back ache, joint stiffness, arthritis, and in infantile paralysis and other conditions.

FEVER THERAPY BY PHYSICAL MEANS

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During the past few years, interest in the production of fever by physical means has greatly increased. More than 600 articles have been written and published on the subject. Excellent research work has been done, and conservative scientific conclusions have been drawn. The value of fever therapy as an important therapeutic agent in the treatment of certain diseases has been definitely proved.

The treatment of more than fifty diseases by means of artificial fever therapy has been attempted. The results in the majority of these diseases were not encouraging, although with a selected few the method has given promise of great usefulness. It must be emphasized, however, that fever therapy is probably of little or no value in the treatment of many diseases concerning which its use has been studied, and in some diseases it may even become dangerous.

GENERAL PRINCIPLES

Numerous studies on the effects of fever produced by physical means indicate that these effects produce certain definite changes in the body.

Effects on Circulation.—The pulse and circulatory rates are increased by fever therapy, and both the volume output of the heart and the velocity of the blood may be increased by as much as 400 per cent. There is an initial increase which is followed by a decrease in the pulse pressure. There is a marked increase in the pulse volume in the fingers of the patient in all types of artificial fever with the exception of that caused by foreign proteins. It has been suggested that the vasodilatation which occurs during fever produced by foreign protein is possibly of central origin, whereas that which occurs in artificial fever induced by external

From the Section on Physical Therapy, the Mayo Clinic.

heating, with consequent prevention of loss of heat, is chiefly of peripheral origin.

The maximal increase of circulation in artificial fever occurs, in general, at temperatures between 103 and 104 F. (39.4 and 40 C.). Alterations appearing in the electrocardiogram are not uniform. The electrocardiograms show disappearance of the normal sinus arrhythmia, and the cardiac rhythm becomes remarkably regular. The conduction time (PR interval) is shortened about 0.02 to 0.06 second during the elevation of bodily temperature, being shortest at 105 F. The conduction rate concomitantly slows to its former velocity as the temperature falls.

Studies made by means of sphygmograms, phlebograms and electrocardiograms of patients undergoing fever treatments indicate that the total filling time of the ventricle is rapidly reduced by the time the temperature is elevated to 100.5 F. and reaches its lowest figure at 103.5 F. After this, the filling time increases slightly, so that it again becomes greater than the emptying time.

The curves illustrating filling times suggest that both the distressing symptoms and the subjective discomfort often experienced by patients during the induction of artificial fever might be accounted for by an inadequate filling of the heart because of an insufficient duration of the filling time. Compensation may be accounted for by a more adequate ventricular filling brought about by an increase in the duration of the filling time.

There is little or no change in the volume of the blood and no change in the viscosity of the blood when the intake of fluids is encouraged during the fever sessions. Artificial fever unaccompanied by sweating does not of itself bring about any considerable change in the blood volume, but when fever is accompanied by profuse perspiration, the reduction in blood plasma may be so great as to produce peripheral vascular collapse.

Recent studies have been made on capillary resistance during artificially induced fever therapy. It has been found that negative pressures at levels between 20 and 30 cm. of mercury are necessary to produce capillary hemorrhages under normal circumstances. Twenty minutes after a patient is placed in the fever cabinet, there appears in all instances an increase in the ease with which capillary hemorrhages can be produced.

The readings are reduced to 10 or 15 cm. of mercury, which are definitely abnormal. When the patient is removed from the cabinet there is a rapid decrease in the ease with which the hemorrhage can be produced. This is noted regardless of the duration of the treatment. Within a few minutes after the patient is removed from the cabinet, pressures ranging from a minimum of 25 to a maximum of 65 cm. of mercury are required to cause hemorrhage. It is believed that the tendency toward hemorrhage in the visceral organs is dependent on capillary resistance and that this tendency is probably greatest when the patient is first removed from the cabinet at the end of the treatment. Because of this fact, the capillaries of the skin become highly resistant and constricted, and there is a shift of the distribution of blood to the viscera which may result in dilatation and rupture of the capillaries. These studies indicate that at the end of the treatment it is best to reduce the temperature of the cabinet slowly instead of taking the patient out of the cabinet suddenly. The latter procedure will produce a rush of blood from the periphery to the viscera.

Absorption of fluids from the intestinal tract may be retarded during high fever, but the intravenous administration of fluids permits rapid restoration of blood volume. The visible capillaries of the nail beds are increased in number and size. The erythrocyte count generally is not changed. There is an initial decrease in the number of leukocytes, with a subsequent increase. There is a leukocytosis which starts during the fever period and rises in tidelike fashion with the addition of waves of neutrophilic cells and then gradually recedes to prefebrile levels in from twenty to twenty-four hours. This leukocytosis is varied, the total cell count ranging from 10,000 to 60,000.

Prolonging the fever, especially at high temperatures, delays leukocytosis or at least produces a smaller increase in leukocytes than does a shorter or less intense session of fever. It has been shown that continuous high fever in the rabbit prevents leukocytosis and may eventually lead to leukopenia. This action is explained by a progressive fall in the lobe index (number of nuclear lobes per hundred polymorphonuclear leukocytes), indicating that the bone marrow is pouring cells

into the blood but is unable to keep pace with the emigration of these cells to the tissues.

Sessions of fever produce nuclear changes in the polymorphonuclear leukocytes, and these changes are in part toxic and in part the result of accelerated metabolic activity. There is a tendency to hypersegmentation and to the production of macropolycytes.

Bone marrow which has been previously stimulated but which is not being actively depleted by demands made by the tissues will respond to artificially induced fever by marked leukocytosis. Conversely, bone marrow which is being stimulated actively but which is also being drained by demands of the tissues will respond with only slight leukocytosis. This is illustrated by the slight response to the malarial paroxysm which occurs late in this disease. The same bone marrow, after a period of recuperation following quinine treatment, will respond by marked leukocytosis when subjected to artificial fever.

Studies of the effect of artificially induced fever on the coagulation of the blood indicate that a decrease in prothrombin and fibrinogen may occur following hepatic damage. Artificially induced fever may produce relative and absolute thrombocytopenia. Megakaryocytes undergo definite plasmic and nuclear damage. The degree of thrombocytopenia produced depends on the extent of the megakaryocytic damage. It is believed that elevation of the bodily temperatures results in anoxemia and a depletion of the glycogen in the liver. These in turn will cause hepatic and megakaryocytic damage. Such damage may interfere with coagulation of blood and thus contribute to the development of potential or actual hemorrhage. Therefore, during fever therapy, particular attention should be paid to the metabolism of minerals, carbohydrates, oxygen, vitamins and water in order to avoid irreversible changes and serious permanent damage or death to the patient.

Histologic studies of organs of animals subjected to fever sessions continuously until death disclose focal accumulations of polymorphonuclear leukocytes which often reach the proportions of abscesses. In the lymph nodes there is early and progressive destruction of the lymphocytes followed by polymorphonuclear infiltration and later by a marked proliferation of actively phago-

cytic clasmatocytes. At this later stage, the nodes thus involved are hypoplastic without evidence of lymphocytic regeneration.

There is slight, if any, change in the nitrogenous constituents (urea, uric acid and creatinine) of the blood. There is a consistent increase in the clearance of the creatinine content, in contrast to wide variations of the clearance capacity which occur during infection. There is little or no change in the non-nitrogenous constituents, such as sugar, phosphorus, lipids and calcium, except, occasionally, for a slight increase, which in turn depends on an increase in concentration of the blood. There occurs no significant decrease in the lipids of the plasma such as is seen in the presence of acute infections. There is usually an alteration in the acid-base equilibrium of the blood which tends to produce slight alkalosis. Marked alkalosis may be noted. It has been concluded that fever characterized by severe dehydration and hyperventilation induces pronounced alkalosis. The degree of alkalosis which approaches critical levels is dependent on the severity of the dehydration and on the extent of hyperventilation. Opinions vary as to the effect on the hemal concentration of the chlorides. Some investigators claim that there may be a marked decrease in this concentration, whereas others declare that there is no significant change. If salt or a weak saline solution is administered by mouth during treatment, the hemal concentration of chlorides diminishes very little. If no sodium chloride is administered, profuse sweating and a diminished concentration of chlorides are to be expected. It has been noted that in seven cases the development of jaundice followed prolonged fever therapy. Two significant effects common to each case were found: (1) the increase in the icteric index was accompanied by a low value for the serum chloride and a diminished excretion of urinary chlorides and (2) the jaundice could be relieved only by the administration of large amounts of sodium chloride, and not by the administration of carbohydrates. Proper attention to the chloride and water balances "is apparently the most important factor in the technic of administering prolonged fevers." The oxygen content and oxygen-combining power of venous blood are increased. Opinions also vary as to the effect of artificial fever on the agglutinins of the blood, but the agglutination

titer is generally within normal limits. The action of complement-fixing antibodies is temporarily diminished, but there is no change in the opsonic index. In studies on the effects of fever, great modifications in the antibodies of normal and syphilitic patients following fever were found. Studies made by means of a calorimeter on the mechanism of heat loss from the human body showed that "the mechanism for heat loss is adequate to care for twelve times the basal heat production" and that "spontaneous fever is due almost entirely to malfunction of the mechanism for heat loss."

Other Effects.—Examination of the effects of fever therapy on the gastric contents reveals a sudden decrease in the amount of chlorides and an increase in the amount of lactic acid. The urine is increased in amount, but temporary oliguria generally occurs. The reaction of the urine is unchanged, but the urine may be slightly alkaline and its specific gravity may be increased. The basal metabolic rate is increased approximately 7 per cent for each degree of fever induced. Cold fluids taken by mouth produce fluctuation in the gastric temperature but do not appreciably affect the general temperature. The comparison of the temperatures observed in the median antebrachial vein, rectum, uterine cervix, Hunter's canal, bladder and spinal canal indicate that records of the rectal temperature provide an accurate index to the temperature of the deep tissues. After each treatment there may be a temporary loss of weight as a result of loss of fluids unless sufficient fluids are taken by mouth, but this lost weight is quickly regained and after a course of fever therapy a patient usually retains his original weight or even gains weight.

PATHOLOGIC CHANGES

Hemorrhagic encephalitis and hemorrhagic pneumonitis have been noted in some instances in which extreme hyperpyrexia was induced. Deterioration of, and hemorrhage into, the cortex of the suprarenal gland may occur after induction of such hyperpyrexia. In the large viscera of laboratory subjects killed by hyperpyrexia there were found regions of focal degeneration and cloudy swelling. It has been observed that no demonstrable changes in nerve tissues occur in laboratory animals whose temperatures were elevated to

111.5 to 111.9 F. for from thirty-three to seventy-five minutes. Rabbits which were subjected until death to febrile temperatures not exceeding 108.3 F. were seen to have peripheral nerves characterized by degenerative changes of the reversible type. Intensity of the changes was directly proportional to the degree of febrile temperature induced in each animal. In rabbits subjected to intermittent periods of induced fever (during which the average bodily temperature varied between 106.1 and 107.8 F. for a total of from eighteen to fifty hours with one week of recovery time allowed between the last exposure and the time of killing) the peripheral nerves exhibited only mild intensities in the reversible types of degenerative change. If the bodily temperature of the animals was raised to 107.6 to 108.5 F. for eight hours and thirty days intervened between the time of exposure and the time of killing, the nerves showed a marked return to the normal status. Inferential evidence presented with this study indicated that regional anoxia was a contributing factor of considerable importance in the causation of the degenerative changes in the peripheral nerves observed after artificial fever.

At necropsy after death resulting from the induction of artificial fever, as observed in the experimental laboratory and elsewhere, pathologic lesions have been found which are similar to the lesions discovered at necropsy after death caused by the administration of nitrous oxide anesthetic. These lesions would seem to indicate that death may result from anoxia.

Probably the actual fatal mechanism in some cases in which sudden death has occurred during hyperpyrexia is extensive hemorrhage into the endocardium of the left ventricle and also hemorrhage into the septal wall in the region of the bundle of His.

BACTERICIDAL EFFECTS

Neisseria gonorrhoeae is generally destroyed by a temperature of from 106 to 107 F. (41.1 to 41.6 C.) in from six to twenty-seven hours. In a high percentage of cases of syphilis, dark field illumination will not reveal the presence of Spirochaeta pallida after the patient has been treated with fever induced by physical means. Mycobacterium tuberculosis, Streptococcus haemolyticus or Streptococcus mitior when exposed to temperatures within physiologic ranges in vitro show

no cultural changes. Micrococcus catarrhalis, Haemophilus conjunctivitidis, Haemophilus influenzae, Brucella abortus, Escherichia coli, Eberthella typhosa, Streptococcus haemolyticus, Streptococcus viridans and Diplococcus pneumoniae (type I and type III) usually resist a temperature of 107 F. (41.6 C.) in vitro for twenty-four hours; an occasional strain shows some reduction in number.

There is evidence that, in vitro, elevations of temperature greatly increase the streptococcicidal power of certain sulfonamide compounds. These observations may explain the apparent beneficial effects of combined fever-sulfonamide therapy in treatment for several cases of subacute bacterial endocarditis.

DESCRIPTION OF APPARATUS

There are various devices for the production of artificial fever. The most common devices used at present are the air conditioned cabinets, luminous heat cabinets, air conditioned cabinets used in conjunction with short wave diathermy, electric blankets and zipper bags or blankets used in conjunction with short wave diathermy.

Air conditioned cabinets produce a rise in the bodily temperature by circulating hot, humid air over the body. Hyperpyrexia is produced by the heated air. The dry air temperature of these cabinets is usually maintained at between 110 and 130 F., and the humidity is maintained at as high a percentage as possible (from 80 to 95). These cabinets are heated by small radiant heaters similar to the units found in the household electric heater. The humidity may be maintained by a 1,000 to 2,000 watt immersion heater placed in a pan of water. The air is circulated by means of small fans. This type of cabinet can be used with entire satisfaction to produce artificial fever without the aid of a diathermy apparatus. Several such cabinets are on the market.

There is a luminous heat cabinet which is similar in its action to the air conditioned type except that it is heated by four or five 200 watt carbon filament bulbs situated in the top of the cabinet. It has a fan and humidifying pan with which to circulate and humidify the air. This type of cabinet can be constructed easily by any hospital carpenter for from $150 to $250.

Short wave diathermy machines have become very efficient in the production of artificial fever. The most satisfactory means of using short wave diathermy is to employ it in conjunction with an air conditioned cabinet. Fever is induced by means of the short wave electromagnetic cable or electrostatic plates; the bodily temperature is maintained by means of the air conditioned cabinet.

High frequency currents, short wave diathermy and, likewise, conventional diathermy can be used in conjunction with blanket packs or bags with slide fasteners. This procedure is satisfactory for administering short sessions of fever but is not satisfactory for the production of prolonged high fever. The blanket pack or the bag with slide fastener exerts an extremely confining effect on the patient, so that it is almost impossible for him to withstand many hours of fever. Various kinds of electric blankets, some of which are designed in the form of a large sleeping bag, have been constructed for use in fever therapy. They are less expensive than cabinets, but their great disadvantage is that the patients enveloped within them are closely confined. These blankets, if employed at all, should not be used when a temperature of more than 103 or 104 F. (39.4 or 40 C.) is required. None have yet been approved by the Council on Physical Medicine of the American Medical Association.

Hydrotherapeutic Methods.—The production of fever by means of hot baths is still being used successfully by some investigators. Although prolonged hot tub baths are enervating, they elevate the patient's temperature rather rapidly and may maintain it at a fairly high level for from one to two hours. After the fever has been induced by means of the bath it can be maintained by means of blankets or, better still, by means of a simple radiant heat cabinet.

The simple tub bath is as inexpensive and uncomplicated as any method of producing fever. It seems likely that as physicians continue their search for simpler and better methods of producing artificial fever by physical means, they will more frequently elevate the temperature by means of hot baths and maintain it with a radiant heat cabinet.

In administering the hot spray bath, the nude patient is placed in a cabinet in the supine position with his

head protruding from one end, as if he were lying in an air conditioned or other type of heat cabinet. He is then sprayed with a series of very fine jets of nebulized hot water, the temperature of which is controlled by means of a thermostat. This spray cabinet will produce a rapid rise in bodily temperature if the temperature of the water can be maintained at the proper degree. One supposed advantage of this method is the fact that the thermostat can be switched immediately, thus releasing a momentary spray of cold water. The brief spray of cold water will exert a refreshing effect on the patient; at the same time, if the switch to the cold water is maintained for a brief time only, there will be an increase in the bodily temperature instead of a decrease. Apparently the momentary contraction of the peripheral capillaries caused by the cold spray drives the warm peripheral blood into the splanchnic regions, thus producing an additional and a more rapid increase in the systemic temperature. The chief detriment to the use of the spray cabinet is that the operator must depend on a general water supply as the source of heat, and it is rarely possible to obtain a constant flow of sufficiently hot water.

A new apparatus has been developed which produces a highly humidified atmosphere similar to that within the older spray cabinets. This machine is heated and humidified by means of a self-contained heating and nebulizing mechanism. There is a large tank of hot water in the base of the cabinet. The water in the tank is kept at proper temperature by means of a thermostatically controlled heating element. A motor forces the water from the tank through small nebulizers which throw a fine spray of water throughout the cabinet. This machine works on the same principle as the older spray apparatus but does not have the disadvantage of having to be dependent on the central plant for its supply of hot water.

Other Conduction Methods.—A simple method of inducing hyperpyrexia by wrapping the patient in blankets and rubber sheeting has been used. With this method, no source of heat other than the natural heat of the body is utilized; however, four or five hours is necessary in which to elevate the bodily temperature to 104 F. (40 C.), which would seem to be an unnecessarily long period of discomfort before the required

high temperature is achieved. If this method is to be used, it would seem expedient to use at least a few hot water bottles in the patient's wrapping in an attempt to induce the fever more rapidly.

In using the hot water bottle and blanket method, the patient is simply wrapped in a number of thick blankets and surrounded by a number of hot water bottles. The great disadvantage of any blanket method of inducing hyperpyrexia rests in the fact, as has been indicated, that nearly all patients are rendered extremely uncomfortable by the confinement of their limbs occasioned by the necessarily tight wrapping of so many heavy coverings.

PERSONNEL

A carefully trained team consisting of technicians and a physician is essential to the safe conduct of fever therapy. The personnel of the fever therapy department is almost as important as the personnel of the operating room. A competent physician familiar with all the reactions which can be evoked by this type of therapy should be in attendance at all times during the treatment. The treatments should be administered by registered nurse-technicians who have been trained for at least one month or six weeks in a well organized fever therapy department of a hospital or under the close supervision of some person who has had such training. It has been said "The percentage of cooperative patients is directly related to the expertness and the tact of the nurse in charge." Failure to achieve a measure of success with fever therapy in many institutions arises from the fact that the attending nurses have not been adequately trained and familiar with the physiological principles that are essential to effective treatment. For many reasons the use of fever therapy should be confined to institutions. It must be borne in mind at all times that fever therapy is not without danger. Though it is entrusted to a corps of highly trained workers, serious complications can and do occur during its administration.

TECHNIC

Selection of Patients.—Emphasis cannot be laid too strongly on the need for careful selection of patients. The patient should be subjected to a careful physical examination before treatment, and if there is any degree of hypertension, cardiac disease or severe

debility he should be rejected. Functional disorders of the heart need not contraindicate fever therapy, and under satisfactory control patients with diabetes may also be accepted. Pulmonary tuberculosis may not be a contraindication per se, but the associated respiratory involvement may prevent the satisfactory elevation to, and maintenance of, high temperature. Fever therapy is not contraindicated by the presence of subacute carditis or inactive rheumatic heart disease; on the contrary, it may be of benefit in such conditions. In general, it might be said that any contraindication to major surgical procedures is likewise a contraindication to this type of therapy.

Management of Patients During Treatment.—Fever therapy is not tolerated uniformly by all patients; as is the case with other types of therapy, toleration depends on the reactions of the individual patient. The average person should be told what to expect of the treatment, should be enlightened as to the various physical changes that will occur and should be informed that the treatment is severe but not intolerable. Persons who have no idea of what to expect during the fever treatment frequently become extremely nervous, so that they cannot be controlled for the desired length of time. There is a certain group of extremely nervous, easily excitable persons who will not tolerate the treatments.

The most common untoward results observed during fever therapy are headache, restlessness, nausea, vomiting, tetany and muscle cramps. Heat prostration may occur. Restlessness requires sedation, which may be repeated every two or three hours. There is considerable variance of opinion concerning the best sedative, but in the experience of most workers codeine, pantopon, dilaudid and morphine sulfate have been satisfactory. It has been contended that carbamide sedatives are more satisfactory for basic sedation than the barbituric acid group of drugs. The latter are respiratory depressants and may also increase the danger of hemorrhage and patchy necrosis of the central nervous system. Such hemorrhage and necrosis may be produced by anoxia which often exists during fever therapy or simply by the barbiturates when administered in toxic doses. Therefore, the combination of barbiturates and fever seems ill advised. It seems essential to keep

the patient quiet but never in a state of narcosis sufficient to prevent his reacting to questioning. Nausea and vomiting may be controlled by intravenous injections of from 500 to 1,000 cc. of 5 per cent dextrose and 1 per cent sodium chloride in solution during the treatment. Tetany may be corrected readily by the intravenous injection of 10 cc. (approximately 2½ fluidrachms) of calcium gluconate. From a study of the metabolism of chloride and water it has been concluded that the maintenance at a high level of the patient's intake of fluid and sodium chloride is of the utmost importance. For the average six to ten hour period of fever treatment, a total intake of from 3,000 to 5,000 cc. (3 to 5 quarts) of fluid has been found effective. An intake of sodium chloride of at least 20 Gm. (approximately 5 drachms) will cover the chloride loss in perspiration for the average treatment. The maintenance of fluid and chlorides may be accomplished easily by having the patient drink from 3 to 6 liters of a solution of 0.3 or 0.6 per cent sodium chloride, iced, during the session of fever. The patient may also be allowed to drink sweetened tea, orange juice, lemonade and carbonated beverages. He should be instructed to ingest a meal rich in carbohydrates on the night before a fever treatment. In some cases an intravenous injection of from 500 to 1,000 cc. of a solution of 5 per cent dextrose in physiologic solution of sodium chloride should be made on the morning of treatment.

The skin of the patient should be observed frequently during treatment. If a region of erythema appears on any part of the body, that region should be protected by a towel. If the erythema becomes more prominent, a cold cloth or a piece of ice may be applied. By observing such precautions and by elevating the patient's temperature gradually, one can prevent what might otherwise develop into severe burns.

When air conditioned cabinets are used, the dry air temperature should be maintained between 106 and 120 F. (41.1 and 48.9 C.) in association with high humidity and low air velocity. With this procedure, there is little necessity for covering the patient and burns of the skin are infrequent.

Episodes of delirium occur not infrequently during prolonged high fever. Delirium, unless it is violent, does not contraindicate continuance of the treatment.

There is usually an increased oxygen saturation of the venous blood during the early part of a fever session but later if there is circulatory failure there may be a severe anoxemia and anoxia. The factors producing this anoxia are increased temperature of the blood and the resulting increased demand for oxygen in the tissues and, in some instances, failure of circulation. Oxygen inhalation is an important factor during fever treatments. At one time oxygen tents were used over the heads of patients in fever cabinets in an attempt to increase the effectiveness of therapy, the assumption being that the high oxygen saturation of the blood thus obtained might be an important factor in the curative effect of the fever. With bodily temperatures of from 101.8 to 105.9 F. (38.8 to 41.1 C.), the oxygen content of the venous blood was observed to be considerably elevated. When the bodily temperature was elevated and oxygen was also administered, the percentage oxygenation of the hemoglobin frequently was found to exceed 95; however, a clinical estimate of the procedure indicated that the combination of oxygen and fever was only slightly more effective against disease than was fever alone. It was decided, however, to consider the use of oxygen in conjunction with fever therapy only from the standpoint of additional safety to the patient. The oxygen tent was found cumbersome and difficult to use, because most patients objected seriously to being entirely enclosed. The use of nasal catheters has been suggested, as has also use of the so-called face tent.

More recently, use of one of the two types of the new Boothby-Lovelace-Bulbulian oxygen face masks has been found effective. The mask is laid lightly over the patient's nose and he is permitted to inhale oxygen at intervals during one half to three fourths of the entire treatment. The adjustment is so arranged as to permit a partial rebreathing and a partial admixture of atmospheric air. Patients do not object to this type of mask, because it is light, readily applied and easily lifted off at any moment to allow sponging of the face and administering of fluids by mouth. The intermittent administration of oxygen during all fever treatments is an important additional safety factor in the prevention of the dangerous after-effects of anoxia that have been so clearly described by a number of investigators.

There should be a well trained fever therapy nurse in constant attendance on the patient. At no time should she be more than a few feet away. The pulse rate, temperature and respiratory rate should be recorded every fifteen minutes for the first hour of therapy and every ten minutes thereafter. A careful record should be made of the amounts of fluid intake and also of the reactions of the patient. The temperature should be taken during the first hour by both mouth and rectum and thereafter by rectum exclusively. Electrical indicating thermometers are extremely convenient and satisfactory and their use allows the nurse-technician to give more attention to the patient. The blood pressure should be recorded every hour during the treatment. Any untoward reactions of the patient seen by the technician should be reported immediately to the physician in charge, who should be within calling distance at all times.

COMPLICATIONS

Mention already has been made of the reactions that may occur during a session of fever, such as headaches, nausea, vomiting, tetany and abdominal cramps. Nausea and vomiting also may be present during the evening after treatment, although they are usually relieved within twenty-four hours. Herpetic lesions on the lips and in the mouth, nose and pharynx may be so severe as to render eating and drinking difficult for a time. These lesions tend to disappear even though fever treatments are continued at regular intervals.

Occasionally superficial burns occur, especially on the arms and chest. However, these usually do not interfere with subsequent sessions of fever, and they can be avoided in practically all cases if the precautions previously mentioned are followed.

One of the most serious complications is circulatory collapse with a possibly fatal termination. Circulatory disturbance may occur during treatment in spite of the more careful antetherapeutic examination and even though the condition of the patient is apparently good during the treatment. In cases of circulatory collapse, the usually accepted treatment for shock is administered. Not only a rise of the temperature above safe physical limits but other serious consequences may be avoided by discontinuing treatment whenever any of the following conditions are found: (1) a systolic blood

pressure of less than 80 mm. of mercury, (2) a pulse pressure of less than 20 mm. of mercury and (3) a pulse rate of 160 beats or more which is constant for more than thirty minutes. Often in the presence of these conditions cooling the patient momentarily may result in an improvement that will last throughout the treatment. It is now known that circulatory collapse occurring during fever therapy may be caused by the loss of fluids resulting from excessive perspiration. If the systolic blood pressure recedes below 80 mm. of mercury during the treatment, intravenous injection of from 500 to 1,000 cc. of physiologic solution of sodium chloride containing 5 per cent dextrose should be started at once. This is a most important safety measure; it will often permit continuation of treatment by replacing the lost fluids and by raising the blood pressure to within safe limits.

Another complication of a serious nature, infrequently encountered, is heat stroke. The patient's temperature rises suddenly to 107 F. (41.6 C.) or above. The pulse becomes hard, but its rate is not increased in proportion to the elevation of temperature. The blood pressure increases and coma and pulmonary edema may suddenly develop. The patient should be removed from the cabinet immediately and cooled by means of a tepid sponge bath and by a fan which blows cool air directly on the body. This procedure is considered preferable to the use of ice baths, which may contract the peripheral capillaries and lessen heat radiation. If pulmonary edema and apparent cerebral edema occur, the patient should receive a solution of hypertonic dextrose (50 per cent) by intravenous injection or a venesection should be done. The temperature may rise rapidly to 110 F. or more, with fatal results, or return to normal. If it returns to normal, care should be taken that the patient's condition does not proceed to a state of shock accompanied by a subnormal temperature.

THERAPEUTIC INDICATIONS

As is the case with many new therapeutic agents, artificial fever has been recommended for the treatment of a large number of diseases. As mentioned previously, it has been used for no less than fifty different ones. Space does not permit detailed consideration of the use of artificial fever produced by physical means in the treatment of all the conditions for which it has

been recommended or used, which are as follows: adiposis dolorosa, allergic dermatitis, bronchial asthma, bronchiectasis, Buerger's disease, cerebral atrophy complicated by chronic otitis media, chorea, chronic sinusitis, dermatitis herpetiformis, epidemic encephalitis, epilepsy, infections of the gallbladder, gonorrheal arthritis, gonorrheal corneal ulcer, gonorrheal endocervicitis, gonorrheal epididymitis, gonorrheal prostatitis, gonorrheal salpingitis, gonorrheal urethritis, pelvic inflammatory disease, Hodgkin's disease, infectious arthritis, interstitial keratitis, subacute iritis, meningococcic septicemia, multiple sclerosis, mycosis fungoides, optic atrophy, osteogenic sarcoma, osteomyelitis, Parkinson's syndrome, peripheral vascular disease, psoriasis, psychoses, radiculitis, Raynaud's disease, rheumatic fever, sciatic neuritis, scleroderma, syphilis, syphilitic meningitis, ocular syphilis, syphilis of the nervous system, trichinosis, tumor and undulant fever.

It must be emphasized most strongly that fever therapy is probably of little or no value in the treatment of a number of these diseases. It would be distinctly dangerous to use fever therapy in some of the diseases for which it has been recommended. Among these may be mentioned: arteriosclerosis, subacute bacterial endocarditis, hepatic infections, pyelitis, staphylococcic septicemia and tuberculosis. Recent studies have added greatly to information on the treatment of some diseases by artificial fever; such studies should be consulted before artificial fever induced by physical means is employed to treat the disease in question.

Subacute Bacterial Endocarditis (Endocarditis Lenta). —The use of artificial fever therapy alone in treatment for subacute bacterial endocarditis was abandoned because apparently it increased the danger of embolism. Nevertheless, because experimental studies indicate that elevation of temperature may increase the effectiveness of the sulfonamide compounds, an attempt has been made to combine hyperpyrexia with sulfonamide therapy. Some experimental studies indicate that physically induced hyperpyrexia enhances the value of chemotherapy in subacute bacterial endocarditis and clinical results with the combined procedure seem to justify its continued employment in treatment for this almost universally fatal disease.

Bronchial Asthma.—Despite the fact that in a fairly large number of cases of intractable bronchial asthma fever therapy has brought about favorable results, it is felt that it should not be attempted in such cases unless all other means have failed. The results are frequently only temporary, and in some instances no improvement can be obtained. In no instance should fever therapy be attempted as an office procedure. It is the opinion of one investigator that hyperpyrexia of itself will be of only temporary, if indeed any, value but that when it is used in conjunction with other forms of treatment it is a most valuable adjunct.

Chorea.—The total number of cases of chorea treated by artificial fever induced by physical means is still too small to permit formation of any final conclusions. The studies do indicate, however, that the treatment of chorea by this method should be continued in well equipped institutions. Several investigators have found that choreiform movements cease in as many as 80 per cent of cases. Other investigators have reported more than 400 attacks of chorea for the alleviation of which the patients received fever therapy. Sixteen patients who had suffered from associated rheumatic carditis were also benefited. Comparative analyses of ninety-five cases in which the patients received fever therapy and of seventy-five in which they did not disclose a definitely lowered incidence of rheumatic manifestations among those patients who received fever therapy. Fever therapy was effective in cutting short an attack of chorea. The presence of associated active carditis was not a contraindication to its use; in fact, the carditis was perhaps benefited by it. The immediate results were excellent and recovery occurred in the majority of cases. The procedure of treatment for chorea has varied with different investigators, but in general it is believed that ten or twelve sessions of from two to three hours daily, with bodily temperatures maintained at from 104 to 105 F. (40 to 40.5 C.), form the procedure of choice. Some workers, however, have employed from four to six sessions, each of which was from five to eight hours in duration, maintaining the bodily temperatures between 104 and 105 F. (40 and 40.5 C.) and repeating these sessions every third or fourth day. Typhoid vaccine has been used with satisfactory results, the temperature being raised to 104 or

105 F. (40 or 40.5 C.) and maintained at a constant elevation for from five to six hours by means of a blanket pack. It is felt, however, that the fever therapy produced by physical means is more easily controlled and that children will accept and tolerate it more readily.

Gonorrhea.—The effects of artificial fever therapy produced by physical means on gonorrhea and its complications are conclusive. Reports by several investigators are available concerning the pyrexic treatment of gonorrhea in a large series of cases. More than 1,000 cases of gonorrhea treated by artificial fever induced by physical means have been recorded during the past five years. The percentage of remissions in the series of cases previously mentioned has been approximately 90. The rationale of the application of fever therapy to gonorrhea has been based of course on the thermolabile properties of the gonococcus.

When fever therapy was first used for gonorrhea, the patient's bodily temperatures were raised to from 106 to 107 F. (41.1 to 41.6 C.) and maintained at this level for six hours. The patient usually received from three to ten treatments, administered every third day. Later it was found that when gonorrheal infections were treated for periods equal to or slightly less than the thermal death time of the gonococcus, there was usually destruction of that organism. Many workers began to use fever sessions of long duration, the usual session being ten hours, maintaining the bodily temperatures at from 106 to 107 F. (41.1 to 41.6 C.). The duration of the treatment administered at 106.7 F. (41.5 C.) may be sufficient to equal 85 per cent of the thermal death time of the gonococcus and yet fail to result in a cure; on the other hand, treatment brief enough to equal only 10 per cent of the thermal death time occasionally results in a cure. The variation in effectiveness is probably influenced by the condition of the defense mechanism of the body. In the use of single fever sessions of ten hours' duration with bodily temperatures maintained at from 106 to 107 F. (41.1 to 41.6 C.), the results have been most satisfactory. In 94.6 per cent of ninety-nine cases there was remission after an average of 1.1 sessions, each ten hours in duration.

Since the introduction of sulfonamide compounds into therapeusis, the need for artificial fever in treating gonorrhea has become less; however, there remains a

certain percentage of patients who cannot tolerate sulfanilamide or with whom sulfanilamide does not eradicate the disease. For these the combination of sulfanilamide and hyperpyrexia has proved most efficacious.

There is evidence that sulfonamide compounds and fever therapy in combination are more effective in the treatment of gonorrhea and its complications than is either treatment alone. The combination will permit the use of safer, shorter fever sessions at lower levels. This combination is particularly useful in those cases in which the patient fails to respond to chemotherapy alone.

Gonorrheal Arthritis.—In most cases startlingly good results have been obtained with artificial fever in the treatment of gonorrheal arthritis. Most reports show that approximately 60 to 80 per cent of the patients become symptom free and that an additional 10 per cent are markedly improved; the other 10 per cent remain unimproved. The results are better when the treatment is instituted early in the course of the disease than when it is delayed until the disease has reached a chronic stage. The procedure used in the treatment of gonorrheal arthritis is the same as that for gonorrhea in general.

Other Gonorrheal Complications.—Gonorrheal ophthalmia has been shown to respond readily to fever induced by physical means, results revealing themselves in the form of subsidence of the inflammation, disappearance of the organism from the conjunctival tissues, acceleration of healing and a shortened stay in the hospital. Gonorrheal endocervicitis, gonorrheal prostatitis, gonorrheal salpingitis, gonorrheal pelvic inflammatory disease and gonorrheal endocarditis have been shown to respond favorably to prolonged high artificial fever. In the treatment of gonorrheal infections in the female, it has been found advantageous by some investigators to use local pelvic heating in conjunction with fever therapy. This may be done either by using vaginal applicators with which to heat the pelvis by a high frequency current or by using Elliott vaginal applicators with hot water as the thermal agent.

Infectious Arthritis.—About 30 per cent of one group of patients with infectious arthritis who were treated with artificial fever were significantly improved. The

other 70 per cent exhibited little or no improvement. Fever sessions of short duration, during the course of which the bodily temperatures are elevated to from 101 to 103 F. (38.3 to 39.4 C.) by means of fever cabinets and hot baths, have been used; in conjunction with other corrective physical therapy they have appeared to be of benefit.

Meningococcic Septicemia.—Recoveries from this disease following the use of intense fever (of seven to ten hours in duration), with the temperature at 106.8 F. (41.5 C.), have been reported. Certain strains of meningococci were seen to exhibit a reduction in growth when they were maintained in culture at temperatures ranging from 40 to 42 C. (104 to 107.6 F.). Five strains were destroyed or greatly reduced in number within five hours or less. Fever therapy seems worthy of trial in selected cases of meningococcic infection.

Multiple Sclerosis.—The results of fever therapy in the treatment of multiple sclerosis for the most part have been unfavorable, although the number of cases reported is still too small to permit the formation of final conclusions.

Mycosis Fungoides.—After the induction of artificial fever by physical means, several patients having this disease were seen to obtain moderate improvement; however, the permanency of the improvement has not been established.

Neuritis.—Low fever has been recommended as a safe and efficient means of treating neuritic and radicular pains.

Parkinson's Syndrome.—The use of artificial fever therapy for the condition causing this syndrome has not been particularly satisfactory. In seeking relief from this syndrome, it would probably be best to heed the statement "Fever therapy in the form of diathermy or malarial or bacterial injections seems to produce no permanent benefit. It may even do harm."

Rheumatic Fever.—It would seem that the treatment of rheumatic fever by artificial fever may sometimes be justified. After the use of artificial fever therapy in a small series of cases, patients often reported considerable relief of pain and swelling of the joints; there was a reduction in the leukocyte count and a decrease in the sedimentation rate of the erythrocytes.

In a comparative study of a small series of patients, some treated by means of artificial fever and some untreated, there was a striking reduction in the percentage of polyarthritis and also in the deaths from heart disease in the fever-treated group. Further analysis of the patients who had heart disease showed that the severity of the cardiac lesion was considerably greater in the untreated group; however, the two groups were small and the observation periods were not sufficiently long to warrant any final conclusion. The procedure used in the treatment of such patients usually consists of sessions of fever therapy four or five hours in duration with bodily temperatures maintained at from 104 to 105 F. (40 to 40.5 C.).

Syphilis (Early Primary).—Preliminary clinical investigations seem to indicate that, when artificial fever therapy is combined with chemotherapy, better results can be obtained than by the use of either form of therapy alone. However, in its present stage of development, fever therapy could not possibly be made available to the average patient having a primary syphilitic lesion. When the bodily temperature has been elevated to more than 105 F. (40.5 C.) for fifty hours in ten sessions of five hours each, this procedure being combined with thirty injections of an antisyphilitic chemical agent, cutaneous manifestations of the disease, including chancres, have been reported to respond with surprising promptness, so that no living, motile spirochetes can be found in any of the primary lesions after the first fever treatment. Progressive improvement in serologic reactions has appeared in the majority of cases. The results of treatment in control groups for which either fever therapy or chemotherapy was used indicated that neither of these methods alone was as effective as the combined procedure.

Dementia Paralytica.—The use of artificial fever produced by physical means in the treatment of dementia paralytica is becoming more and more extensive; however, there is still insufficient evidence available for the investigator to conclude that such fever will be more or less satisfactory than malarial fever. Most observers who have made careful comparative studies feel that fever produced by physical means offers a slightly higher percentage of immediate clinical remissions than does therapeutic malarial fever; however, it has been

claimed by certain authorities in the field of syphilology that the relapse rate for physically induced fever will be higher than that for malarial fever. Certainly it will be several years before any final conclusions can be drawn; nevertheless, the best available comparative studies indicate that 70 per cent of patients with dementia paralytica who were treated with physically induced fever were immediately benefited by the treatment and that two years and eight months later 66.6 per cent of them remained improved; whereas, of a control group treated by malarial therapy, 63.3 per cent were improved immediately and two years and eight months later 56.6 per cent remained improved. These observations seem to indicate that the response of dementia paralytica to physically induced fever is apparently as well sustained as improvement brought about by therapeutic malaria. Much larger series of cases will have to be studied before final conclusions can be drawn.

Tabes Dorsalis.—It is generally agreed that patients with tabes dorsalis may be benefited by physically induced fever. Some investigators feel that tabetic pains and gastric crises respond more rapidly and with greater certainty to physically induced fever than to therapeutic malarial fever. Again it must be stressed that the number of cases collected is not large enough to permit formation of any final conclusions. As additional evidence is collected, however, it becomes more apparent that physically induced fever may be of great value in the treatment of syphilis, particularly the tertiary manifestations of the disease.

Other Forms of Syphilis.—A number of investigators have reported encouraging results following the use of physically induced fever in the treatment of ocular syphilis, and there have been favorable reports also on the use of fever therapy for tabetic dementia paralytica, meningovascular syphilis and asymptomatic neurosyphilis.

Tuberculosis.—The study of the effect of fever therapy on dogs which had been subjected to experimental tuberculosis disclosed a temporary improvement, and as compared with that of control dogs, life was prolonged. Investigations, however, indicate that in the presence of tuberculosis, artificial fever therapy should

be employed only with great care even in experimental studies. There is grave danger of doing harm to the patient if fever therapy is used for this disease. The study of this phase of the treatment of tuberculosis should for the present remain entirely in the hands of research workers.

Undulant Fever.—Several investigators have noted that in a total of about 90 cases of undulant fever there has been a rather striking response to fever therapy. About 80 per cent of the patients treated exhibited definite clinical remissions with prompt disappearance of symptoms or definite improvement; however, the number of patients so treated is still insufficient to permit formation of final conclusions concerning the effectiveness of fever therapy. The procedure has been to administer five hour sessions of fever with bodily temperatures maintained at between 105 and 106 F. (40.5 and 41.1 C.); usually from one to three such treatments are necessary.

Conclusions with Respect to Diseases Treated.—Studies made to date seem to indicate that the chief sphere of usefulness of fever induced by physical means lies in the treatment of gonorrhea, both acute and chronic, and its complications. It would appear that artificial fever may be of value in the treatment of syphilis, particularly when it is combined with chemotherapy. While there is a suggestion that artificial fever produced by physical means may be helpful in the treatment of intractable bronchial asthma and in selected cases of chronic infectious arthritis, chorea and undulant fever, the clinical data are not sufficient to permit formation of any final conclusions. Its value in about forty other diseases remains to be proved. It seems to offer promise of considerable usefulness as a therapeutic agent.

CONCLUSIONS

Continued study has emphasized the fact stressed by the Council on Physical Therapy, namely that production of fever by physical means is strictly a hospital procedure, that it is essential that a well trained personnel be in complete charge of the work, that skilled nurse-technicians who have had at least one month's supervised training administer the treatments and that a physician be in constant attendance.

Patients to be treated by fever should be selected with as much care as those who are to undergo major surgical operations. The dangers that have been mentioned, embolism, hemorrhage and sudden death, are extremely rare when the administration of fever is in the hands of a competent, well organized group. However, it is to be expected that there will be a slight mortality resulting from a treatment that is as heroic as this one. If the treatments are given without proper control or are considered simple office procedures, there will be danger of harm to the patient or even death.

Opinions vary as to the best and safest means of producing fever. Almost any one of the methods described in this article may be used with the confidence that it will produce favorable results, provided the team of workers has developed a good technic for the particular method to be employed.

PHYSIOLOGY OF MASSAGE

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Explanation of the influence of massage has been long in forthcoming, although use of the measure itself, as already noted, goes back to the earliest periods of history. Clinical medicine and successful forms of treatment often run ahead of precise knowledge of the premises from which they arise. It becomes important, however, and even necessary, sooner or later, to acquire such precise knowledge. This is eminently the case with that measure of therapy known as massage. Knowledge of the nature of the influence which massage exercises is desirable not only on physiologic grounds, and because of the light thus incidentally thrown on pathologic processes favorably affected by it; especially today is it important to refer, as far as possible, the alleged benefits from this measure to definite facts and principles rather than to clinical impressions, with the aim of counteracting the obloquy that misuse of massage has, in some part, cast on it. There is probably no other measure of equal known value in the entire armamentarium of medicine which is even yet so inadequately understood and utilized by the profession as a whole.

Although the clinical results of massage are undoubted and often graphic, it has been and still is difficult to determine the factors that are most directly operative. A great deal of investigative work was carried out in the latter part of the last century, more or less contemporaneously with the development of the so-called Swedish school of physical therapy, and in 1910 Rosenthal [1] reviewed the literature to date in a monograph on the scientific basis of massage. Since that time, however, more modern methods of physiologic and chemical investigation have been developed, but the subsequent literature from this standpoint has not been extensive. Many of the data to be derived by

1. Rosenthal, Carl: Die Massage und ihre wissenschaftliche Begründung, Berlin, 1910.

studies along these lines are of a negative nature, but they serve nevertheless to delimit the problem in a fairly satisfactory manner.

A review by Pemberton and Scull [1a] describes the influence of massage as a summation of several physiologic components. Reduced to its simplest terms, massage involves the application of the stimulus of pressure to tissues. The most obvious response to pressure is a direct physical influence upon distribution of material in the vascular and lymphatic structures of tissues, in ducts and in the gastro-intestinal tract. In any of these structures, application of external pressure would be expected to displace their contents, gaseous, fluid or semisolid, into regions subjected to lesser pressures.

Variable pressures are normally exerted upon tissues of this kind during the course of physiologic activity. Rhythmic alternation of pressure is well evidenced in respiratory movements and in the automassage thereby exerted upon the visceral organs. When stimuli are modified in disease, as in the case of ankylosis of the thoracic cage, or decreased diaphragmatic excursion, secondary changes may conceivably ensue in the activities of adjacent viscera.

Similarly, normal skeletal muscular activity involves changes in contour of muscle masses. These alterations in shape exert variable pressures on blood vessels and lymphatics included within the muscular tissue. When muscular activity is reduced, by disease or injury, automassage is diminished and return of fluids through the veins and lymphatics is modified. Secondary stasis in veins and lymphatics might be expected to follow. This is sometimes compensatory and compatible with those essential functions which vascular channels support and lymphatic channels drain but secondary consequences may be disadvantageous. Sustained stasis of lymph favors fibrosis. In order to prevent irreversible transformation of active tissue cells into inactive tissues, attempts at correction of lymphatic stasis are often indicated. Used to this end, therapeutic massage constitutes a replacement of auto-massage and in this sense may be regarded as substitution therapy. While full substitution may appear incapable of full realization, inasmuch as it would require almost continuous appli-

1a. Pemberton, R., and Scull, C. W.: Massage. Medical Physics, Ed. O. Glasser, Year Book Publishers, Inc., Chicago, 1944.

cation of external massage, this is impractical in most instances and might not be completely equivalent to auto-massage in any case. Some approximation can be achieved, however, whereby massage is carried out with regard to both anatomic arrangement and physiologic function of the parts. Much of skeletal muscular activity is intermittent and not continuous, so that at least for clinical purposes massage at short intervals could achieve the purpose of substitution.

In addition to direct mechanical displacement of fluid in vascular and lymphatic channels, massage acts to expedite removal of toxic or foreign materials from focal lesions. Dissolution of foreign or pathologic deposits by means of the direct influence of pressure induces an associated increase of blood flow.

Rhythmically alternating pressures are sometimes employed to discharge fluids from the lungs and initiate respiratory movements after drowning and asphyxia. Mechanical respirators and suction and pressure boots used to promote circulatory efficiency in limbs possessing inadequate blood supply likewise involve massage. Although these agencies are not usually included under this heading, these several procedures depend upon displacement of materials, gaseous or fluid, from certain areas by means of externally applied pressure and involve a summation of the physical influences which are associated with massage.

Massage achieves more than physical displacement of material within the vascular channels of tissues. Sensory and reflex nervous responses are induced by application of pressure to cutaneous and muscular areas. Neurovascular adjustments secondary to direct pressure therefore assume considerable importance in the total response following massage.

The lightest form of massage, consisting of light stroking of the skin, known as effleurage, induces relatively slight effects. The larger vascular and lymphatic channels are not directly influenced. While the finer superficial channels are both directly and indirectly affected, it appears probable that central nervous influences are also important. Effleurage provides rhythmic stimuli to the organs of touch which may be registered centrally in various ways, one of which is vaguely comforting and conveys a sense of contentment.

The application of greater pressures produces effects which are greater than those of effleury. A strong stroke over the skin of the forearm, for example, may be seen to produce blanching, followed by hyperemia. This effect may be intermediated by release of histamine and/or acetyl choline from the tissue or partly by the brief temporary anoxemia from lack of blood in the compressed area. The response in any event is a dilatation of the cutaneous vessels with increased volume of cutaneous blood flow. The principal effect may be primarily local if the area is small. If the cutaneous area involved is large, probably comparatively massive shifts in blood distribution may be brought about. Such massive redistribution of blood might involve removal of blood otherwise stagnating within the splanchnic or other areas.

In addition to neurovascular responses, massage may induce significant neuromuscular activity. Whether this is a result of direct stimulus to muscles or secondary to neurovascular response is not certain. Among arthritics neuromuscular disturbances such as twitching and spasm are not uncommon and massage affords significant relief from these symptoms.

A number of the investigators of thirty or more years ago observed an increased excretion of urinary nitrogen following massage. Bendix [2] and Voight [3] carried out more carefully conducted experiments in which the food intake of the subjects studied was controlled. These workers independently observed an increased excretion of nitrogen during the twenty-four hour period in which massage was administered, and a heightened excretion of urinary nitrogen continued decreasingly for several days after the administration of massage. According to Eccles [4] there takes place an increased output of uric acid on those days during which massage is given. In line with these indications of the influence of massage on metabolism were the observations of Leber and Stüve,[5] who reported an increase of from 10 to 15 per cent in the oxygen consumption and carbon dioxide production following either general or abdominal massage. Diuresis has been a consequence

2. Bendix, B.: Ztschr. f. klin. Med. 25: 303, 1894.
3. Voight, O. W.: Inaug. Diss., Halle, 1896.
4. Eccles, A. S.: Practice of Massage, London, 1898.
5. Leber and Stüve: Berl. klin. Wchnschr. 33: 337, 1896.

frequently observed by many workers,[6] and this diuresis may persist for several days.

In the attempt to ascertain more accurately the specific influence, if any, of massage on certain factors in metabolism, an effort was made by Cajori, Crouter and Pemberton [7] to determine the rate of excretion of several other constituents of the urine. For this purpose the hydrogen ion concentration, titratable acidity, sodium chloride, inorganic phosphorus, total nitrogen, creatinine and creatine were noted. The increased volume of urine noticed by others was again observed, especially after abdominal massage, and occasionally there was a true diuresis. It is probable that this diuresis is due in part to the abdominal pressure exercised, as Griffith and Hansell [8] found diuresis to occur following abdominal pressure alone, and Bazett and his associates [9] observed it following pressure of water on the abdomen during immersion of the body in a bath. Herxheimer, Kost and Wissing,[6] however, believed the diuresis to be referable to a direct effect on the muscular tissues, either mechanical or by way of the nervous system. It is probable that the direct muscular influence and the abdominal influence are independent.

In the work of Cajori et al [7] the excretion of acid was not observed to be altered after massage, and there was no disturbance of the acid-base equilibrium of the blood. An increased rate of excretion of nitrogen, inorganic phosphorus and sodium chloride was observed more frequently following massage than during the control period. The rate of excretion of creatinine was apparently not influenced, and in no case was creatinuria induced. Kost [10] and Schneider [11] found, in contrast to the earlier work of Leber and Stüve,[5] that oxygen consumption was not influenced by the customary forms of massage unless associated movement was

6. Herxheimer, H.; Kost, R., and Wissing, E.: Ztschr. f. d. ges. phys. Therap. **33**: 167-182 (June 30) 1927. Hirschberg, R.: Bull. gen. de therap. **113**: 241, 1887. Pemberton, Ralph; Cajori, F. A., and Crouter, Caroline Y.: The Physiologic Effect of Massage, J. A. M. A. **83**: 1761 (Nov. 29) 1924. Cuthbertson, D. P.: Quarterly J. Med. **25**: 387, 1932.

7. Cajori, F. A.; Crouter, Caroline Y., and Pemberton, Ralph: The Physiologic Effect of Massage, Arch. Int. Med. **39**: 281 (Feb.) 1927.

8. Griffith, J. Q., and Hansell, H. R.: Am. J. Physiol. **74**: 16 (Sept.) 1925.

9. Bazett, H. C.; Thurlow, S.; Crowell, C., and Stewart, W.: Am. J. Physiol. **70**: 430 (Oct.) 1924.

10. Kost, R.: Ztschr. f. d. ges. phys. Therap. **33**: 1 (Feb. 18) 1927.

11. Schneider, E.: Zentralbl. f. Chir. **55**: 390 (Feb. 18) 1928.

induced. Cuthbertson [12] confirmed Kost and Schneider in that he found no immediate or delayed effect on the basal consumption of oxygen, pulse rate, or blood pressure in normal persons. In contrast to the essentially negative effect of massage on various phases of metabolism in the normal subject the above author [12] noted a significant influence from massage in the direction of a retention of nitrogen, sulphur and phosphorus, essential to tissue repair, in patients convalescing from fractures of the long bones.

In general, therefore, the results described suggest broad and generic influences are exerted by this measure, that while massage has no immediate or large effect on general metabolism per se. The cumulative effect which massage exercises on various metabolic processes probably lies, as Rosenthal believed, in its mechanical influence on the circulation of the parts concerned.

Attention should be directed to other studies which further substantiate this general point of view and make it possible more nearly to define the general nature of the influence of massage.

It is generally recognized that massage achieves some of its best results, especially over limited areas of the body, when preceded by exposure of the given part to external heat. The complementary action of these two measures is therefore worthy of attention. Furthermore, it is generally believed that massage, exercise and exposure to heat constitute a triad of measures or agencies which more or less replace one another in the treatment of certain pathologic conditions, such as trauma to joints or muscular tissue and rheumatoid or arthritic processes in them. In a study of the respective physiologic influences of these three measures, however, certain sharp differences may be detected. With exposure of the whole body to heat, for instance, there takes place an acceleration of the rate of respiration and of the general circulation. One consequence of the increase of respiration is a washing out of carbon dioxide from the lungs. Sweating is also induced, and a small amount of carbon dioxide, together with small quantities of other acid products such as lactic acid, is eliminated. Salt and some nitrogenous constituents are also carried away in the sweat. The urine normally contains carbon dioxide and various

12. Cuthbertson, D. P.: Glasgow Med. Journal **200** (Dec.) 1933.

quantities of acidic substances, such as phosphates, sulfates and organic acids; but, following systemic exposure to heat, the amounts of these substances in the urine are increased.

The net result of these several processes is the removal from the body of certain acidic radicals, chiefly carbon dioxide, which create within the body a state of relative alkalosis. The relative excess of alkali left in the blood is in turn eliminated through the sweat and the urine, producing an alkaline swing in each of them.

This general condition of relative alkalosis of the fluid tissues of the body following exposure to heat is in marked contrast to the results of exercise. Thus, Barr and his co-workers,[13] following the work of Haldane, have shown that actively contracting muscles bring about the production of lactic acid in amounts sufficient to change the reaction of the blood in the opposite direction, namely, toward acidosis. This increased acidity may persist for as much as fifty minutes after an amount of exercise equivalent to 3,500 kilogram meters in three and one-half minutes. This is about comparable to the amount of exercise taken by a man weighing 150 pounds (68 Kg.) climbing 150 steps at the rate of one step a second.

While massage partakes somewhat of the nature of exercise, studies from the chemical standpoint show that this is not wholly the case. After massage, given as vigorously as clinically practicable to individuals unaccustomed to it, there develop none of the evidences of acidosis, such as follows active exercise. There is no increase of lactic acid in the blood, and no constant increase of organic acids in the urine as would presumably be the case if lactic acid were produced and eliminated in the manner described by Wilson.[14] After massage of considerable severity the hydrogen ion concentration of the blood shows no change comparable in magnitude to that following exercise of the extent mentioned. There takes place in some cases a slight decrease in alkalinity, corresponding to changes observed by Barr after very mild exercise. It is to be borne in mind, however, that the massage administered was as vigorous as could be tolerated within therapeutic limits. There was furthermore no change in the percentage

13. Barr, D. P.; Himwich, H. E., and Green, R. P.: J. Biol. Chem. **55**: 495 (March) 1923.
14. Wilson, D. W.: Proc. Soc. Exper. Biol. & Med. **21**: May 24, 1924.

saturation of the blood with oxygen, such as follows exposure to heat, and there was therefore no evidence of a heightened rate of circulation. The oxygen capacity rose slightly, though unmistakably, a point that has a significance to be mentioned later.

Massage is accompanied, therefore, by neither the alkaline swing following exposure to heat nor the acid swing following active exercise. The apparent absence of detectable changes in the chemical equilibrium of the tissue fluids, adequate to explain the benefits resulting from massage, emphasizes the persumable influence of the mechanical factors accompanying and characterizing it. In this connection, Krogh and his co-workers have amply demonstrated the effect of external stimuli on the capillary circulation. Carrier[15] has shown that

TABLE 1.—*Comparison of Certain Metabolic Responses Following General Application of Massage, Heat and Exercise*

	After Heat	After Exercise	After Massage
Hydrogen ion (p_H) concentration			
Urine	Increase 0.6	Decrease	No change
Blood	Increase 0.26	Decrease 0.14	No change
CO_2 capacity of blood (volumes per cent)	Increase 5	Decrease 15	No change
Lactic acid of blood (mg. per 100 ml.)	No change	Increase 65 mg.	No change
Oxygen consumption	Increased	Increased	No change

light pressure produces an almost instantaneous though transient dilatation of the capillary vessels, although heavier pressure may produce dilatation of more enduring nature. Microscopic observation of fields in which only a few capillaries are open, and hence in which only a few can be seen, reveals that pressure of this kind may cause practically all the smaller vessels to become visible because of the blood flow created through them. According to A. E. Cohn,[16] this general response may occur in very young blood vessels that are not innervated and is then apparently a direct function of the intensity of the stimulus.

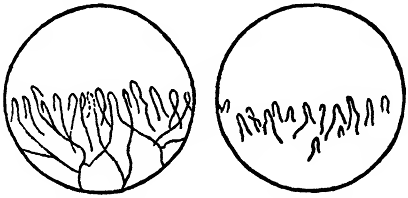
A possible mechanism by which the vasomotor response is achieved is suggested by Ruhmann.[17] This author noted that the increased skin temperature and

15. Carrier, E. B.: Am. J. Physiol. **61**: 528 (Aug.) 1922.
16. Cohn, A. E.: Read before the Cosmopolitan Club meeting, Rockefeller Institute, New York, March 22, 1930.
17. Ruhmann, W.: Med. Wochen **68**: 163, 1933.

vasodilation of the arterioles after the local application of acetyl-choline is similar to the reaction produced by local massage. Because of this similarity, the hypothesis is advanced that acetyl-choline is released from the tissues by the mechanical stimulus of massage and that this endogenously derived material then exerts its pharmacologic effects.

Recent cinematographic studies by Clark and Swenson upon the capillary circulation in the ear of a rabbit, utilizing the permanent window for observation, have revealed actual changes in the vessel walls which permit of the passage of leukocytes. Following massage there is an increased rate of blood flow and a change in the

MASSAGE OPENS CAPILLARY BEDS



Before **After**

vessel wall which is evidenced by the "sticking" and emigration of leukocytes. Massage is thus accompanied or followed by an increased interchange of substances between blood stream and tissue cells, which presumably promotes an altered and heightened tissue metabolism.

The application of alternate suction and pressure as employed by Landis[18] appears to constitute in some measure a variation of massage, in that tissue volumes are mechanically altered. Evidence derived from the use of this procedure indicates that an improvement of circulation occurs. The influence exerted on the total quantity of blood flow through a massaged area, and in the direction of sweeping along the stagnant cells lying inactive within it, needs no emphasis.

Further evidence illustrative of such an influence is to be seen in the effects of general massage on the blood count. Mitchell[19] showed in 1894 that in both

18. Landis, E. M., and Gibbon, J. H.: Proc. Soc. Exper. Biol. & Med. **30**: 593, 1933.
19. Mitchell, J. K.: Am. J. M. Sc. **107**: 502, 1894.

health and anemia the red cell count is increased after massage and this observation has been corroborated by Pierce and Pemberton.[19a] This is especially the case in anemia, according to Mitchell, in which condition the increase is greatest one hour after treatment, beyond which period it slowly diminishes. Schneider and Havens[20] have also shown that abdominal massage alone will increase the hemoglobin and red cell count in blood taken from the finger at ordinary barometric pressures. These workers have demonstrated that, following acclimatization to altitudes, the extent of such increments diminishes and the increments themselves finally cease. They interpret this finding as due to the lowered barometric pressure, which brings into the circulation many red corpuscles usually contained within closed or inactive areas.

TABLE 2.—*Systemic Massage Raises the Red Cell Count*

	Red Blood Cells	Difference
Case (1) Before	3,448,000	
After	4,024,000	+576,000
Case (2) Before	4,008,000	
After	4,200,000	+192,000
Case (3) Before	4,008,000	
After	4,480,000	+472,000

Scott,[21] however, believes that concentration of the blood affords the explanation. At all events, the influence of massage in the direction of an increase in the hemoglobin and red cells of the peripheral circulating blood is beyond question, whether or not any factors additional to the mechanical influences are operative. The limited but definite rise observed, as already mentioned, in the oxygen capacity of the blood after massage also bears this out. It is difficult, therefore, to escape the conclusion, already mentioned, that while the direct influence of massage is on the local circulation of the parts treated, there is an indirect but no less important influence on the circulating fluids of the body as a whole.

In contrasting the effects of active muscular exercise and those of passive muscular exercise in the form of

19a. Pierce, E. J., and Pemberton, R.: Unpublished data.
20. Schneider, E. C., and Havens, L. C.: Am. J. Physiol. **36**: 380, 1915.
21. Scott, F. H.: Am. J. Physiol. **44**: 298 (Oct.) 1917.

massage, another point of importance emerges. An overflow of lactic acid into the circulating blood, and hence a systemic acidosis, may follow relatively mild exercise. As pointed out, massage may be given so vigorously as to be nearly comparable in severity to mild exercise without producing changes in acid base balance. Evidences of this severity are to be seen in the sense of fatigue experienced by the subject of excessive massage. It would therefore appear justifiable to conclude that, whereas lactic acid is produced by contraction of muscle following volitional effort on the part of the individual, it is not produced, at least in sufficient amounts, as the result of extraneous mechanical stimuli applied to the muscle within therapeutic

TABLE 3.—*Systemic Massage Raises the Oxygen Capacity of the Blood*

		Oxygen Capacity per Cent by Volume
Case (1)	Before	15.4
	After	15.9
Case (2)	Before	15.0
	After	15.1
Case (3)	Before	17.2
	After	17.4
Case (4)	Before	17.8
	After	18.6
Case (5)	Before	17.8
	After	18.2

limits, to give rise to a systemic acidosis. This conclusion is of importance because it seems to explain the value of massage to the exercised muscles of athletes. This beneficial influence of massage is well known to athletic trainers and is widely utilized by them in connection with traumatized muscles. Were it not for the fact that massage produces no important additional amounts of lactic acid, its favorable influence on overexercised muscle could hardly be explained. In the absence of any further burden in this regard, changes in the blood supply of muscle brought about by massage presumably permit more rapid or more thorough removal of the lactic acid already contained within such tissues.

While the more subtle physiologic and chemical changes following massage are difficult of measurement, it is easy to recognize clinically the mechanical value of this agency in returning fluid from the fixed

tissues to the general circulation. This may well be seen in a gross way by observing the effect of upward stroking and massage on edema of the extremities following cardiac decompensation, and especially on edema, partly secondary to the dependent position of the feet, sometimes encountered in chronic arthritis.

Quantitative data bearing on the influence of external pressure on the movement of fluid through the human capillary wall have been adduced by Landis.[22] Following the application of a pressure cuff to an extremity fluid accumulates in the tissue spaces. As the point of saturation is reached the filtration rate into the tissues was found to be decreased by an amount representing a tissue pressure as high as 35 cm. water.

The possibility that the beneficial effects accruing to the arthritic from massage are exerted partly through the lymphatics involved, is demonstrated by the work of Bauer [23] who showed that certain proteins injected into the joints of dogs are removed by way of the lymphatics. It was further demonstrated that the rate of elimination through these channels is increased by massage and passive motion of the legs.

It would be improper to suppose that the general effects of massage on the circulation are brought about through mechanical agencies alone. There can be small doubt that the nervous system contributes under massage, probably through the sympathetic division, to a reflex influence on the blood vessels of the parts concerned. Dilatation of the small vessels accompanying blushing and following very light stroking affords illustration of the nervous mechanism operating. It is probable, therefore, that vessels within the muscular system or elsewhere are emptied during massage not by virtue alone of being squeezed but also through this reflex action. Because of this, or for other reasons, there seems to be an indirect effect exercised on the organism as a whole which may take the form of mild stimulation, mild sedation or exhaustion. Under appropriately controlled circumstances, this influence should be mildly sedative or slightly stimulating but never exhausting.

Finally, as mentioned in the section on the technic and practice of massage, it is important to bear in

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22. Landis, E. M., and Gibbon, J. H.: J. Clin. Inv. **12**: 105, 1933.
23. Bauer, W. W.; Short, C. L., and Bennett, G. A.: J. Exper. Med. **57**: 419, 1933.

mind that in inactive persons, such as those confined to bed, massage may compensate for lack of that contraction of the muscles of locomotion upon the larger blood vessels which normally contributes to the return of the venous blood to the heart. This influence of massage is available in certain stages of cardiac decom-

TABLE 4.—*Known and Probable Influences of Massage* *

	Primary or Early Effects	Secondary or Late Effects
Vascular system	Release of histamine with acetyl-choline Vasodilation	Increased flow Increased red blood cell platelets Sticking of emigrating leukocytes Decreased pooling of blood in splanchnic area Discharge of red cells from spleen
Peripheral lymphatics	Emptying	Decreased trend toward fibrosis
Striated muscle	Stimulation to contraction	Relaxation from spasm
Unstriated muscle	Stimulation to contraction	Discharge of materials
Nervous system		
Deep nerve trunks	Stimulation	Reflex relaxation
Cutaneous sensory nerves	Stimulation	Relaxation of the psyche
Central nervous system	None	Relief of pain
Connective tissues	Friction between parts	Increased elaboration of lubricating fluid
Joints, synovial fluid	None	Increased rate of removal of particulate materials (egg albumin, India ink)
Ducts, channels (noncirculatory)	....	Decreased absorption of toxic materials
Colon, Prostate, Tonsils, Lymph nodes, Path. nodules	Emptying, external Emptying, internal	Accelerated resolution

* From Pemberton, R., Scull, C. W., Massage in Handbook of Medical Physics, Year Book Publ., Inc., Chicago, in press.

pensation, but it is not utilized clinically to the extent that it should be. In addition to the metabolic and circulatory influences of massage already described a number of secondary responses are summarized in table 4.

Referring again to the influence of massage on the end-products of metabolism, it must be borne in mind that a necessary consequence of dysfunction of muscle tissue, for which massage is often indicated, is the pro-

duction in the muscle of some of the metabolic products of dysfunction. Massage is capable of promoting the removal of some of these substances, as is well exemplified in its influence on the extravasations of blood and other kinds of débris consequent on traumatization of muscle or other tissue. The only medium for removal of these substances is the circulation through either the lymphatic or the blood vessel system. It follows, therefore, that the removal of these substances under the influence of massage involves an acceleration of those measures which nature, unaided, attempts. The economy as a whole, therefore, may find it difficult under some circumstances to adapt itself to this added quota, from massage, of the products of faulty physiologic function. In certain individuals, chiefly the elderly and the feeble, this difficulty may express itself in terms of a mild toxemia accompanied by fever. What the substances are that produce this result it is impossible now to say with precision, but the consequence to elderly persons may be the addition of a toxemia other than the one from which the patient is already suffering. This is sometimes a practical matter of great importance, and should be avoided.

In any consideration of massage, mention should be made of one aspect of it which is usually overlooked, namely, rest. Any discussion of the physiology of muscular contraction would include exposition of the processes of recovery which take place during the period denoted by the "resting phase." Rest is indeed as essential to muscular contraction as are the processes of contraction themselves. By the same token, rest should be regarded as an integral phase of the process of massage, without which the influences of massage may be negatived or may even become harmful. As already indicated, massage induces in general the determination of blood to certain regions. It must therefore be obvious that if, following achievement of this purpose, the subject of massage engages in increased activity, muscular or otherwise, requiring that the blood so determined be directed elsewhere, the original purposes will be defeated. Furthermore, in any other attempt at activity subsequent to massage, such activity may be more difficult of achievement or performance than would otherwise be the case because of the determination of the blood at the site of the therapeutic objective.

This principle obtains equally as regards both local and systemic massage, though it is more apparent and more influential in the latter case. The above somewhat oversimplified exposition of the relation of rest to the massage processes indicates the broad principles involved but for the fuller grasp of the subject it will be well to inquire further wherein the processes of rest actually consist. Any full exposition of rest and the recovery of phases inaugurated by it would be beyond the purview of this article but at least the following influences should be specified:

REST IN RECUMBENCY

(1) Promotes even distribution of blood throughout the capillary beds.

(2) Permits passage of tissue fluids into the vascular channels.

(3) Releases the nervous system from maintaining erect posture.

(4) Allows ptosed and dysfunctioning organs to assume normal positions and functions.

(5) Reduces the metabolic load necessary to the supply of energy.

(6) Permits replacement of the metabolic factors characterizing fatigue.

SUMMARY

Massage exerts physiologic influences which can be utilized in the treatment of a wide variety of clinical conditions. Systemic massage increases peripheral blood flow, induces an increase in the level of red blood cells, and leads to an increment in the renal output of water. These several responses are produced without a comparable elevation in oxygen composition, heat production or change in acid base balance. In addition, massage promotes the flow of lymph and can be used to hasten the removal of detritus produced by trauma. The application of massage must be nicely adjusted to the individual situation if its full benefits are to be realized. Massage should be prescribed as an element in a well integrated therapeutic regimen and administered with the technical skill of one familiar with the anatomic and physiologic features of the region treated.

TECHNIC OF MASSAGE

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Massage has certain definite physiologic effects, and the various forms of massage differ in their actions. The superficial stroking massage that should be given in a recent injury is entirely different in its action from the kneading massage used in a joint stiffened by an old injury. A physician would not send an indefinite prescription to a drug store without naming the drug or the dose. Therefore, every physician should know enough of massage technic to prescribe it definitely and to see that his patient gets what he prescribes.

There are three main varieties of manipulations included under the head of massage: stroking, compression and percussion. Vibration and shaking movements are sometimes used.

1. *Stroking Movements.*—(*a*) Superficial Stroking: This consists of the passage of the hand over an area of the patient's skin with a slow, gentle and rhythmic movement. This form of massage aims to produce only a reflex effect. Therefore the movements must be slow, gentle, rhythmic and in one direction. This is a simple form of massage, but the technic can be mastered only by long practice. The four main points must be observed or the reflex soothing effect is lost and the movement becomes irritating.

The time of the movement is slow in order to be rhythmic and the technician's movement is continuous and in the same tempo even when the hand is not in contact with the patient.

To secure the reflex effect the pressure must be gentle. It should be firm but light, with the hand adapted to the contour of the patient's body, a combination which can be secured only with the muscles of the hand relaxed.

Rhythmic movements are also essential to secure an even stimulus. This is attained by making the time identical between the beginning and the end of each

stroke and between strokes. The direction of the movement is unimportant in this form of massage provided it is the same throughout the treatment.

(*b*) Deep Stroking Massage: The aim of this form of massage is to empty the veins and lymphatics and to press their contents in the direction of natural flow.

The essentials here are to have the patient's muscles relaxed to take advantage of gravity, to make the movements deep but not heavy and to make them always in the direction of the venous flow.

It is important to have the patient's muscles relaxed; otherwise muscle contraction will reduce the lumen of the veins and prevent the chief object of this form of massage. To secure relaxation, the patient should always be recumbent even when deep massage is being given to an extremity. Otherwise, when massaging the forearm, one cannot expect to influence the venous flow if the shoulder and arm muscles are contracted.

The recumbent position also enables one to take advantage of gravity as an aid to the venous and lymphatic circulation. For example, when a patient is sitting in a chair with his forearm on a table and his arm hanging from the shoulder, gravity opposes the venous flow. Many a physician in prescribing massage has missed the importance of these details in technic.

With the muscles relaxed deep movement is transmitted to all the structures under the hand. Heavy pressure is not needed, as the venous pressure is slight and a heavy and irregular movement may set up a protective reflex muscular contraction to defeat the purpose of the treatment.

The direction is always with the venous flow. In using this form of massage on the limbs, the proximal segment should be treated in the beginning. If the venous and lymphatic circulation of this area is not improved at the outset, that of the distal segment will be blocked.

2. *Compression Movements.*—(*a*) Kneading: This consists in grasping, wringing, lifting, rolling or pressing a part of a muscle or a muscle group. This form of massage aims to assist venous and lymphatic circulation, to hasten the removal of waste products from muscle, to stretch retracted muscles and tendons, and to aid in stretching adhesions. While it may be used after exercise to remove waste products and thus render

muscles more ready to exercise again, neither this nor any other form of massage can develop muscular strength.

Absolute relaxation of the patient's muscles is essential for effective kneading. Too heavy pressure may force the arterial blood against the stream. Moderation in pressure, and timing and direction of movement are again necessary.

The operator's hand grasps a part of the muscle (or a group of muscles), lifts it up as much as possible, and kneads it. Then the hand moves up a hand's breadth and repeats the same manipulations. One or both hands may be used. When the muscles cannot be lifted, as on the back, the movement may be that of rolling or pressing one muscle over the other. In kneading, a thorough knowledge of the anatomy of the muscles is essential.

(*b*) Friction: This consists in pressing deeply on the part under treatment and moving the hand in a circular direction, moving the superficial over the underlying parts. The effect of friction is to free adherent skin, to loosen scars and adhesions of deeper parts, such as tendons on the back of the hands, and to aid in the absorption of local effusion.

Friction is an important massage manipulation around joints and for the small areas, such as the hand, foot and face.

The movement is done with one or two fingers or a part of the hand closely applied to the skin, motion being over the underlying tissue in small circles or in other directions.

Again, the pressure should be moderate and the movement should have a certain rhythm. This pressure may later be increased progressively, if conditions are favorable.

3. *Percussion Movements.*—(*a*) Clapping consists of bringing the hands, held partly open so that the fingers and palm form a concave arch, alternately into contact with the patient's body. The movement is performed chiefly from the wrists.

(*b*) Hacking is done by striking the area with the ulnar side of the fingers so that the fifth finger comes in contact with the body first and is followed by the others in quick succession.

(*c*) Tapping is done with the tips of the fingers, which are used as in piano playing.

(*d*) In beating, the half-closed fist is used to percuss the body. These movements are mostly used on healthy persons and are usually employed in gymnasiums and in Turkish bath establishments.

The first effect of percussion on the skin is a blanching due to a contraction of the arterioles from the mechanical stimulation. This is soon followed by a redness which is due to a paralytic dilatation of these vessels from overstimulation. This circulatory effect

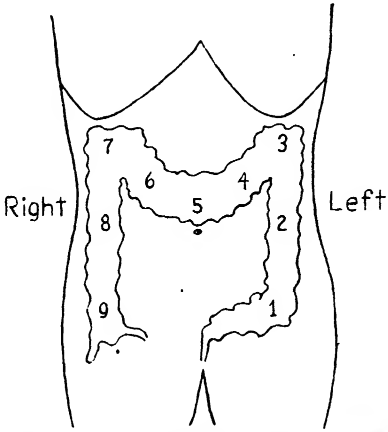

Fig. 1.—In order to avoid massaging against any possible obstruction or partial impaction, begin gentle massage over area indicated by 1, in lowest portion of left abdomen. When this area is soft and free from spasm, massage area at 2 (halfway between left iliac fossa and left lower ribs). When the area at 2 is soft, stroke downwards to 1. Continue thus at 3, 4, 5, 6, 7, 8 and 9, each time going back on your tracks to 1. The transverse colon is drawn in a sagging position as the roentgenogram will show it to be in most patients with sluggish bowels. (Pemberton, Ralph, and Osgood, Robert B.: The Medical and Orthopedic Management of Chronic Arthritis, New York, The Macmillan Company, 1934.)

may be better secured in most cases by other means, such as the whirlpool bath or contrast baths.

Another effect claimed for percussion movements is muscular stimulation. When apparatus is available, this effect may be better achieved in most cases by electrical muscle stimulation.

4. *Vibration and Shaking.*—(*a*) Vibration is performed with several fingers or the whole hand placed firmly on the patient's body while a trembling movement is conveyed by the operator.

(*b*) Shaking is a larger movement of the same kind but is merely coarse vibration. Both vibration and shaking are often employed with one of the three main manipulations.

In movements of deep stroking and kneading made with the muscles correctly relaxed, the effect of vibration and shaking is also achieved. Mechanical means have been devised to give vibratory massage for reducing edema, for loosening scars, and for massage over stiff joints.

Abdominal massage is a helpful measure in treating sluggish bowels and is usually administered incorrectly. The correct method is illustrated in figure 1.

At times it is desirable to instruct the patient or a member of the family to administer heat, massage and exercises to the patient at home. Such instructions are recorded on a mimeographed sheet, for example:

DIRECTIONS FOR HOME TREATMENT

These directions are intended only as a substitute, when skilful massage cannot be obtained, and should, if possible, be carried out by some one other than the patient.

Heat if ordered by the doctor should be applied before the massage.

Be sure the part is relaxed and comfortable and there is no tight clothing to bind.

Massage should never hurt.

Never massage bones or joints if they are at all painful or swollen.

To apply massage, the hand of the operator should be relaxed so that it fits the shape of the part to be treated. The hand should move smoothly over the surface. If the skin is dry, a small amount of cold cream, olive oil or cocoa butter should be used. If moist and sticky, talcum powder may be preferred. Pressure should be firm, but gentle. Never cause pain.

Heaviest pressure should be in the upward direction, toward the heart, very light pressure downward. The hand should be kept in contact with the skin at all times.

The movements used are:

1. Stroking, which is a long smooth movement with even pressure upward, or light pressure downward; the entire hand is used on large muscles, the ball of the thumb on small parts, as the fingers.

2. Kneading; the hand grasps the muscle and gently squeezes and pushes in an upward direction, then relaxes and grasps again. Care should be taken not to pinch. Follow with a light stroke downward.

The treatment should begin with stroking, then a period of kneading and stroking alternately, finishing with stroking.

Order of treatment:

Arm movements reach from elbow to shoulder, then wrist to elbow, than finger tips to wrist. Finish with stroking from finger tips to shoulder.

Leg movements follow the same order as arm.

Shoulder movements extend from back of neck to shoulder tip, chest to shoulder tip, then elbow to shoulder.

Back movements:

1. With hand close to each side of spine, start from lower part and press upward towards neck.

2. Starting at lower part of spine, press outward to the sides, working upwards towards neck.

Length of treatment is about 10 minutes to arm or shoulder and 10-15 minutes to leg or back.

MECHANICAL MEANS FOR MASSAGE AND EXERCISE

Dr. Gustaf Zander of Stockholm, about 1857, was the first to use mechanical means for massage and exercise. His machines will do anything that any of the highly advertised mechanical vibrators will do. These machines were given a trial in this country, and several large hospitals completely equipped Zander rooms. These forms of apparatus have fallen into disuse, as will the present widely advertised mechanical exercisers.

The Council on Physical Medicine of the American Medical Association condemns the sale of these mechanical exercisers to the public for the following reasons:

1. Volitional effort is not encouraged.
2. The same results could be accomplished without an apparatus.
3. Treating only one part does not give any of the advantages of general exercise.
4. The use of such apparatus is monotonous and the patient loses interest in treatment.
5. The effect is that of massage and lacks the physiologic benefits of exercise.
6. Such apparatus is definitely dangerous.

MASSAGE IN ANTERIOR POLIOMYELITIS

It is to be remembered that massage will not restore muscular power. It has no direct effect on paralytic

diseases. It will not help the transmission of nerve impulses from the brain to the paralyzed muscle.

On the other hand, massage has a favorable effect in stimulating the venous and lymphatic circulation and direct manipulation of the muscles also carries away some of their waste products. Therefore massage delays muscular atrophy by inducing better nutrition locally.

As soon as the acute stage of anterior poliomyelitis has passed, as distinguished by the disappearance of pain, massage should be started. This consists at first of only gentle superficial stroking. If the pain reappears, massage should be stopped. In this condition massage ought always to be preceded by heat and followed by muscle training. Splinting should be used to prevent deformities by securing physiologic rest of the paralyzed muscles.

The flaccidity of the muscle deprives the blood vessels of the natural protection given them by proper muscle tone, and as the arterioles are extremely delicate it is easy to overdo the massage, produce paralytic dilatation of these arterioles and increase the condition one is striving to overcome. Therefore the massage should be delicate and given for a short period, and the paralyzed muscle should not be pressed between the fingers or against the bone.

Overuse of massage by too long or rough treatments increases muscular atrophy and diminishes muscular tone by injuring the muscular fibers and causing fatigue.

Treatment of this disease will be considered in a later article.

PERIPHERAL NERVE INJURIES

What has been said about anterior poliomyelitis can be repeated for all peripheral nerve injuries. The treatment here is the daily application of heat, proper massage with gentle stroking and kneading of small areas, and passive joint motions. Electrical muscle stimulation is an aid which, when overused, causes the same effects as overuse of massage. Two or three contractions of each muscle daily is ample. Again, it is important to remember that there is no muscular protection for the delicate vessel walls and only the most gentle manipulations are essential. All deep

kneading, compression and vibration movements are contraindicated. Even in the stroking movements, care must be taken not to compress the muscles against the underlying bone.

Massage in itself is ineffective unless there is proper splintage to prevent the healthy muscles from contracting and the paralyzed muscles from being overstretched. Massage should not be allowed to replace muscle reeducation movements, as muscle strength is increased only by active exercise.

SPASTIC PARALYSIS

Massage is given to prevent muscular atrophy and to increase muscular tone; and in spastic paralysis, except for mild stroking and kneading, massage is contraindicated, as the muscles are in a state of hypertonicity. The stroking should be firm, slow and even. The kneading is performed with the two hands on opposite sides of the limbs and the pressure should be gentle, although here the pressure may be firmer as the muscle tone is increased and there is not as much danger of injuring the muscle or arterioles as in flaccid paralysis.

It is usually an advantage in these cases to precede the massage with heat and to follow it with movement. The difficulty in these cases is to secure motion without exciting spasm.

Massage and passive movements are useful adjuncts to prevent the development of muscular contraction and joint stiffness, but the patient must be made to understand that these maneuvers are not going to restore power in his limb. His participation is essential to reestablish normal impulses from the brain to the muscles. His own effort to accomplish active motion is the most essential element in his treatment.

MASSAGE IN SURGICAL CASES

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MASSAGE IN SPRAINS

Excellent treatment for sprains is frequently given by trainers for various athletic teams. Physicians could learn many important points from these trainers in the technic of the treatment of recent injuries. These trainers are paid to keep men in the game and to get them back quickly if they are injured. The excellent results obtained are due to the trainers' willingness to take time to treat minor injuries and the fact that the patients have the time to devote to the care of an injury. In industry an injury is often thought not serious enough to justify the effort required for proper treatment.

Physicians are so accustomed to treat sprains and strains by immobilization and rest that we neglect the use of proper massage, bandaging and mobilization.

Mennell expressed the keynote of the treatment of recent injuries when he said that we cannot heal torn fibers by massage but can assist in restoring the circulation on which depends the repair not only of these fibers but of all the various tissue injuries that have been sustained.

Torn ligaments, a tenosynovitis and a traumatic arthritis often accompany a sprain. There is hemorrhage from the torn vessels. There is muscular spasm and this, with the local swelling, interferes with the venous circulation. But often there is swelling both above and below the joint which the local conditions could not cause. This is undoubtedly due to a reflex disturbance of the vasomotor mechanism from injury to the nerves.

Therefore the kind of massage used at first is superficial stroking with the whole limb in a position to relax all the muscles and to take advantage of gravity. This massage aims to restore vasomotor tone, preventing further effusion. This is aided between treatments by proper compression—bandaging or strapping. Later,

deep stroking massage and kneading may be used to secure diffusion of the exudate at the site of the injury.

For instance, in the treatment of a severely sprained ankle, the ankle is often tightly strapped and the patient sent home with directions to rest and apply some form of heat. Far better results as to the relief of pain and the restoration of function could be secured if the patient were treated as follows:

The first day the bandage or strapping is removed and, with the patient lying on a couch with a small pillow under the knee and some support to keep the foot straight, heat is applied in some form, either direct diathermy or radiant heat, for twenty minutes. Then superficial stroking massage is begun over the whole foot and leg, the movement being started above the swelling. Deep stroking follows this above and below the ankle, the painful area being gradually approached. The massage is continued for twenty minutes. This is followed by active movement of the knee and toes. The bandage or strapping is reapplied.

If possible, this treatment is given twice on the first and second days, and once on the third day.

The fourth day deep stroking massage, kneading and friction massage are given as on the first day, also relaxed movements of plantar and dorsal flexion of the ankle to the point of pain. The massage should be given over the injured area if there is no pain. Any motion should be limited by the onset of pain. The foot should always be supported when massage or motion is given so as to prevent any further strain of the injured ligaments.

The fifth day the massage is increased over the injured area, and the ankle motion is increased. If strapping or a bandage is correctly applied and the pain and swelling are not severe, walking may be started.

The support of the bandage or strapping is gradually decreased, the firmness of massage is increased and walking is gradually allowed.

These same principles of support, with gradually increasing massage and exercise, apply to all other sprained joints. It must be remembered that in many sprains of the ankles, as well as other joints, firm strapping and immediate use of the joint, in weight bearing, will give equally good functional results. In such cases daily massage would be superfluous treatment.

DISLOCATIONS

In a dislocation there is the same pathologic condition as in a sprain, with more severe tearing of the ligaments and a spasm of the muscles controlling the joint. This is usually so severe as to prevent reduction without an anesthetic. After reduction, this spasm is diminished and the condition is the same as a severe sprain with torn ligaments.

The most frequent dislocation is that of the shoulder, and the most usual after-treatment is to keep the arm tightly bandaged to the side for a week or ten days, thus holding the arm in adduction and internal rotation. This treatment should be abandoned by every surgeon. The position of immobilization should be with the arm abducted and externally rotated. The latter position protects the weak group of muscles, the abductors, the deltoid especially, and prevents undue contraction of the strong adductors, the pectoralis major and the latissimus dorsi. Further, this position overcomes the effects of gravity and aids the circulation. If a dislocated shoulder is treated by strapping the arm to the side of the body, frequently more trouble results from a stiff shoulder after the adhesive strapping is removed than from the original injury.

MASSAGE IN FRACTURES

In the treatment of fractures we strive for end-results showing the greatest amount of anatomic and functional restoration. Neither of these should be neglected for the other. Both will be possible with proper reduction by manipulation, traction or operation; careful fixation with splints and traction, plaster casts or operation, and the use of massage and motion with gentleness, patience and skill. It is to be noted that massage and mobilization are not methods of treatment of fractures but are adjuncts to be used in combination with proper reduction and fixation.

Lucas-Championnière developed massage and mobilization in treating fractures. In his day there were no x-rays and modern bone surgery was not possible, so that fractures were put up in splints for long periods, which often resulted in great deformities and poor functional results. His methods of early mobilization and massage were revolutionary, and, as many patients had poor anatomic results, good functional results were

an improvement. Few surgeons now apply his teachings literally, as it is believed that both a good anatomic result and a good functional result are possible. But these are possible only if massage and mobilization are used with the object of securing function without disturbing the anatomic result. Therefore, in fractures with great displacement of the fragments, massage and mobilization will have to start at a much later date than in fractures with little deformity in which the fragments are easily held in position. In the latter, massage and mobilization used early and with light protective splinting are the principal factors in treatment.

Until union is firm, no massage should be given over the fracture except superficial stroking. When massage is being given in fractures, the danger signs calling for less treatment are increased tenderness, swelling or stiffness in the adjacent joint.

The first treatment of a fracture with massage should last only a few minutes, and only gentle surface stroking should be given. Great care must be taken to support the fracture. The part should be prepared for the massage with heating, followed, if possible, by a small amount of joint motion, if this can be done without displacement of the fracture. All these are gradually increased, bearing in mind that one is striving to secure union of broken bones as well as return of function. There is no injury in which massage and exercise may be used to greater advantage than in fractures. In the early stages the joint movement should be done by the surgeon, the patient being referred to the technician later when union is fairly well started.

In fractures treated with a Thomas arm or leg splint, heat and superficial stroking massage may and should be started early. Some recent research tends to show that callus is formed along the lines of the new blood vessels formed at the site of fractures, and therefore anything aiding circulation in the area of the fractures without producing motion of the fragments should aid in the deposition of callus.

The physician should supervise all early massage of fractures and should give definite directions about the removal of splints, joint motions with or without the splint, and the amount and kind of massage and exercise. Experience has taught us that, when the

surgeon seeks earlier healing and better functional results by the use of massage and exercise, he has assumed a greater responsibility in the case and must guard carefully lest overenthusiasm or errors due to carelessness on the part of the technician may spoil the desired end-results.

STIFF JOINTS

Exclusive of cases of bony ankylosis or cases in which there are pathologic contraindications, massage, exercise and continuous traction or stretching by splints have an important place in the treatment of stiff joints. Adhesions inside or outside such a joint occur in great variety and in a large number of cases are amenable

In this type of stiff joint, deep stroking massage, followed by deep kneading of the muscles above and below the joint, are used. Some one of the methods of heating the limb should precede these manipulations. Friction massage is indicated immediately over the joint. The fingers should work over all the joint, pressing the infiltrated areas and scars. After massage, resistive exercises and passive movements are used.

It is important to remember that such heavy massage, exercises and passive movements may cause some reaction, but if the pain from this passes off in a few hours, it is not detrimental. If it persists longer and there is an increased swelling, injury to the ligaments, muscles and vessels has undoubtedly occurred, with effusion which may organize into more adhesions. In such an event massage and exercises should be abandoned, the joint put at rest and heat applied until the reaction has passed. Then the efforts should be resumed with less vigor.

In the treatment of stiff joints the patient often expects too much of massage and heat. Active exercise and proper splinting are equally important, and it must be explained to the patient that these agents are to be used in spite of temporary discomfort. Proper splinting with continuous traction is of great value and must not be neglected.

AMPUTATIONS

The best preparation for massage of an amputation stump is the whirlpool bath. Stroking and kneading of the muscles and forcible stretching of the tissues toward the stump are given to prevent contractures. The scar

is treated with friction and vibratory massage starting at the periphery and working toward the center. The massage is followed by various exercises, directed first toward maintaining function in the adjacent joints and secondly toward rendering the end of the stump serviceable. Fear of anything or anyone touching the end of the stump is almost universal in patients who have had amputation and is best overcome by massage and exercise.

These manipulations should start just as soon as the condition of the wound will permit, usually by the end of the first week. An excellent means of preparing the patient for these various procedures is to have him start, about the third day, to pound a soft pillow lightly with the end of his stump.

It is well for the surgeon to start giving the massage and exercises to these patients before referring them to a technician. Good results often depend on the proper initial handling of these cases. The exercise of kindliness, patience and encouragement is of the greatest importance to the patient who has had an amputation.

MASSAGE IN INTERNAL MEDICINE

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The word massage is hardly more than a synonym for "rubbing" of some sort in the minds of many practitioners. There are relatively few physicians, speaking generally, who have seen massage applied, in a critical sense of the word; there are still fewer who have tried to use it themselves. Before considering the conditions in which massage may be appropriately applied in internal medicine, it is well to consider therefore the limitations that exist in putting into practice this form of therapy. Obviously, intelligent use of any therapeutic measure demands some knowledge of the benefits to be derived and the dangers resulting from improper or untimely conduction of it. Even an understanding of the physiologic basis of massage does not carry with it practical knowledge of clinical application. Knowledge of the duration of a treatment, the frequency of repetition and the vigor of application are relegated at present to the technician giving the massage. It is important, therefore, to emphasize at this point the extent to which practitioners in general are lacking in a perspective of the subject.

To endeavor to extend to the profession as a whole information regarding the use of massage is not alone sufficient, since it is recognized by those versed in this topic that there is a great dearth of persons trained and qualified to carry out this measure. Concomitantly with extension of knowledge among the medical profession there must therefore be an increase, through a definite policy of education, in the number of those persons trained to conduct the various basal forms of physical therapy, massage in particular. Considerable delay will occur before the situation as a whole can be expected to be rectified, but a beginning has been made in several directions and reform is in process of taking place.

Except in many conditions following trauma, the chief application of massage is in respect to various

chronic conditions and chronic disease states. These fall chiefly under the captions of internal medicine and neurology, although as regards the measure under consideration these clinical fields somewhat overlap. The basis for this generalization, as pointed out in the section dealing with the physiologic influence of massage,[1] lies in the fact that the therapeutic effect of massage is achieved slowly by means of repeated exhibition over a considerable period of time. The influence of any one treatment is or should be, at least at the outset, very slight. The cumulative effect of many treatments is, however, unmistakable. Medical conditions that run an acute course in the space of ten days or two weeks offer, therefore, but little opportunity for benefit from it, although there are perhaps some exceptions to this statement.

The clinical condition with which massage has been longest associated, one indeed that has played a significant part in developing and preserving massage as a therapeutic instrument, is the rheumatoid syndrome. Another field of medicine, however, in which massage has probably had equally recognized application is the treatment of neurasthenia by the so-called rest cure, developed and standardized by S. Weir Mitchell. This will be elsewhere discussed. Massage is also of value in many other conditions and under many circumstances encountered in internal medicine, although such use of it is more or less sporadic and out of keeping with many clear physiologic indications for its employment.

MASSAGE IN CHRONIC ARTHRITIS

In arthritis there is a wide and important field for the application of massage. It may almost be said that few, if any, advanced cases of arthritis of either the atrophic or the hypertrophic type, to follow the nomenclature of the American Committee for the Control of Rheumatism, can be expected to recover without recourse to the principles of physical therapy, intelligently ordered rest and massage in particular.

It is to be appreciated that arthritis is largely a systemic disease and not a disease of joints per se,[2] and that in many cases of the rheumatoid syndrome the

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1. Pemberton, Ralph; Coulter, J. S., and Mock, H. S.: Massage, J. A. M. A. **94**: 1989 (June 21) 1930.

2. American Committee for the Control of Rheumatism, J. A. M. A. **94**: 57-58 (Jan. 4) 1930.

joint structures may be little or not at all involved. It follows from this that other tissues, especially the muscle and tendinous structures, also demand attention.

However, it is important at this juncture to point out that certain differences and limitations inhere in the application of massage to the two main divisions of the rheumatoid syndrome; viz., atrophic and hypertrophic arthritis. Thus, real trauma from any source, including severe massage, will aggravate any existing arthritis and the effects of even very mild sustained trauma, in the form of light massage, may be particularly harmful in hypertrophic arthritis since slight repeated injury is generally recognized as one of the etiologic factors in this variety. Great care must therefore be exercised in the use of massage in hypertrophic arthritis that it be not given over, or too near, the joint structures themselves.

Massage has three chief indications in the arthritic syndrome: First, to improve or maintain adequate conditions of circulation and drainage in the neighborhood of involved joints; second, to improve or correct the faulty physiologic processes in the soft structures and especially the muscles; and, third, to compensate somewhat for the lack of muscular activity that inevitably follows protracted local or systemic disability from arthritis or the rheumatoid syndrome. In this last connection it is thus possible to preserve in considerable degree the normal tone and bulk of muscle structure and even to bring about in atrophied muscles an apparent increase in muscle volume or at least in muscle tone, as evidenced by the resistance and consistency of the tissues under the palpating hand. It should be a cardinal principle in the application of massage in arthritis that treatment should never add by trauma to the inflammatory or otherwise diseased process already present. It follows from this that massage should, for the most part, be practiced in the neighborhood of, but not immediately over, the site of arthritic involvement. There are some exceptions to this statement, in that effleurage of the lightest kind may sometimes be practiced with profit over a diseased joint. In general, however, the principle mentioned must be rigidly adhered to and the instances are legion in which a bad situation has been made worse by undue zeal or by frequency of application. It is to be remem-

bered that most persons who practice massage are technicians without a basal knowledge of medicine, though activated by a commendable zeal for their work. Knowing of the benefits often to be derived, they are not infrequently led to believe that, if a little is good, more will be better and so are led to carry treatment beyond the proper point. They are often encouraged to do this, indeed, by the patient himself, who feels no untoward effects from light treatment and thinks he will do better with a more vigorous application. It is precisely here that the medical profession in general must be educated to the point of knowing, in all clinical conditions, when to limit the application of massage as well as when to prescribe it.

In connection with arthritis, massage can usually be preceded with profit by the application of heat to the involved part. As explained elsewhere, this opens up vascular channels and softens the tissues, permits a more effective application of massage, a larger range of motion of the parts concerned, and generally paves the way for massage itself. When carried out, therefore, with the preceding limitations in mind, a light form of massage in the neighborhood of the involved joint may in itself prove to be a measure of considerable "analgesic" value, as well as contribute to an eventual betterment of the local pathologic disturbance. The reader should be reminded that the processes producing the arthritic manifestations have their basis, in part at least, in marked derangement of the local physiologic equilibrium, especially in the finer circulation. The latter is apparently altered in the direction of vasoconstriction,[3] and the influence of massage, for the reasons elsewhere mentioned,[1] is toward opening up these vascular channels and so restoring the physiologic processes more or less toward normal.

Under nearly all circumstances, massage directed to the neighborhood of joints must be unaccompanied by movement of the joint. "Churning" of the joint is to be studiously avoided. One of the commonest errors made by masseurs in general is that of inducing twisting movements to the finger or other joints, together with passive flexion and extension of nearly all involved

3. Pemberton, Ralph: Arthritis and Rheumatoid Conditions, Philadelphia, Lea & Febiger, 1935.

joints. A subsiding arthritis may easily be perpetuated or made worse by activities of this sort. Furthermore, the question of passive motion in the form of flexion or extension constitutes a small chapter by itself, and the indications should be clear before it is instituted. From the standpoint of possible trauma to the joint structures, many orthopedists believe that passive motion to joints is accompanied more often by detriment than by benefit. There are some exceptions to this, but in any event great conservatism must be adopted toward it. An advantage in directing massage to the tissues somewhat removed from the joint itself lies, thus, in avoiding undue passive movement of the actual joint structure.

One of the sharp therapeutic advantages in recognizing the two chief types of arthritis is in respect to the fact that arthritis of the atrophic type is prone to lead to fibrous and finally to bony ankylosis, depending on the particular apposition of the bones of the joint and on the duration of inactivity. In this type of arthritis motion should be encouraged within the limit of further trauma, preferably in the form of voluntary motion conducted by the patient himself, and this is best achieved after application of heat and massage to the part concerned.

A frequent accompaniment of the later stages of arthritis, at the chair ridden period and especially in atrophic cases, is edema of the dependent parts. This results partly from the vascular derangement accompanying the disease; partly from the absence of muscle contraction to aid in return of the peripheral blood, and partly from gravity alone. This condition is usually accompanied also by a shiny skin and other evidences of a so-called trophic disturbance. In such instances massage is almost the only, and certainly the most important, procedure adequate to rectify the condition and may often appear to work miracles. In these cases and, indeed, in many cases of arthritis, the hands and feet are cold and after a course of massage there may be a marked subjective betterment as well as improvement in the surface temperature and appearance at the periphery.

Because of the systemic nature of the rheumatoid syndrome there also tends to arise an atrophy of muscular tissue referable to a process of "fibrositis" as well as to disuse. Massage, with or without the accompani-

ment of heat, is one of the few measures that will affect this situation. It should be carried out with great conservatism at first and confined to the limbs. As the patient becomes accustomed to the procedure, the whole body should be included at intervals of every other day. The influence of such systemic treatment is not confined to the muscular system per se but, as is elsewhere discussed,[8] exercises a more subtle influence on metabolism as a whole and on the red cells available to the circulation. There are several varieties of technic in the administration of massage but, so far as arthritis is concerned, those methods which embody stroking and gentle compression rather than pinching and squeezing, are preferable. Great force is not necessary, especially on beginning the treatment, and any one can demonstrate for himself the change in the distribution of blood in the superficial capillary bed from even the lightest form of stroking. A definite contraindication to massage, most of all to vigorous massage, is to be seen in cases, arthritic or otherwise, accompanied by fever or by any debilitating complication. The changes in circulation induced by massage may easily be the means of carrying material from one part of the body to another, and any suspicion of malignancy should constitute a contraindication to its use. In such conditions as phlebitis, massage may induce dislodgment into the circulation of fragments of a blood clot, for example, which might find fatal lodgment in the heart, lungs or elsewhere. It is furthermore to be remembered, as already remarked, that muscles which are the site of myositis or other disturbance of physiology, may be and usually are the seat of accumulation of a certain amount of metabolic "detritus." This is almost wholly analogous to the obvious detritus, in the form of extravasations of blood, that accompanies trauma. The unduly rapid absorption of this detritus, produced by massage, may suffice to induce some toxemia and even fever, especially in the elderly.

THE USE OF MASSAGE IN DISTURBANCES OF THE CIRCULATION

One of the fields in which it might be supposed that massage would have an obvious application is that of disturbances of the circulation. Curiously enough, however, in this field massage is but little employed

although at many sanatoriums, in this country and Europe, baths and some form of massage are given more or less as a routine to most patients. The adjuvant mechanical influence of massage in returning tissue fluids and other material from the periphery to the general circulation might have suggested a wide use for it in cardiac decompensation, with or without actual edema, especially as general massage may induce considerable diuresis in normal persons. It is also conceivable that this measure, especially abdominal massage, may be valuable in the treatment of the edema of renal origin, inasmuch as this condition may in part be due to a decreased rate of blood flow through the kidney. Every clinician determines the presence of edema by pressing a finger on the involved part with the aim of determining whether pitting is present. When pitting is thus obtained, it is obvious that the fluids within the tissues concerned have been somewhat displaced. The analogy that this effect could sometimes be exerted on a larger scale throughout a whole limb should be simple, but it seems, indeed, to have escaped large recognition in this country. Thus, reference to a widely used American textbook of medicine reveals no mention of the subject in this connection, although English textbooks not infrequently include discussion of it. In almost any cardiac condition with decompensation accompanied by edema, gravity determines localization of the edema to the dependent parts. These parts are usually the feet, the legs, the buttocks and the back. In such cases, therapy is customarily confined for the most part to rest and restriction of the fluid and food intake, with or without pharmacologic efforts to increase the vis a tergo from the heart. The peripheral tissues of the body are often left to cope as best they may with the fluids in them. In health the circulatory dynamics are aided by contraction of the long muscles, a factor which is, of course, absent in conditions of inactivity and enforced rest accompanying heart disease. Under the latter circumstances, properly given massage may be useful.

Massage is no more a specific in such conditions than is rest or the administration of digitalis, but, together with these and with a suitable curtailment of the diet and fluid intake, it further influences the mechanics of the situation. It must not be overlooked that under

these circumstances massage might conceivably induce undue or too rapid disturbance or resorption of the body fluids or other substances and so induce toxemia. The practitioner should therefore use great caution in the institution of such measures, proceeding to a more vigorous application only when the justifications for this are clear. Massage, in conjunction with the use of heat, may also be of value at certain stages of treatment of disturbances of circulation at the periphery, such as acroparesthesia, Raynaud's disease and intermittent claudication.

There is nothing in the aforementioned considerations, of course, to justify oversight of the broad principles concerned in the management of disturbances in the dynamics of the circulation. It is a purpose of the present article to point out additionally the extent to which the proper use of massage may sometimes aid and abet the various orthodox measures which should be resorted to.

THE USE OF MASSAGE IN ANEMIA

From what has been said in the preceding section and in that treating with the physiologic influence of massage, the implication is clear that massage should have applications of varying extent in conditions accompanied by anemia. The return of red cells to the circulation achieved by massage should be of limited but definite importance in anemic persons. The increase in the red cell count following massage is demonstrable in any normal individual, but it is noteworthy that this influence is apparently more graphic in anemia than in conditions of health.[4] In carrying out massage on the subjects of anemia, great care must be exercised to avoid overapplication. The profession has not as yet utilized this measure in respect to cardiac dysfunction and the various anemias to an extent large enough to justify dogmatism as to the full possibilities of benefit or as to the limitations to such treatment.

MASSAGE IN CHRONIC DISEASE AT LARGE

There is a wide field for the application of massage in almost any condition, devoid of acute or serious complications, which requires that the patient be kept at rest, especially in bed, for long periods of time. The practice of allowing patients to lie or rest in bed,

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4. Mitchell, J. K.: Am. J. M. Sc. **107**: 502, 1894.

without the institution of measures capable of compensating in part for cessation of the normal activities of life, is far too common. Under extreme conditions of inactivity, as in severe and widespread arthritis, the human being may literally flatten out, somewhat as does a piece of putty left on the window sill. Gravity and pressure of the bed from below may produce grotesque lateral deformity, so that the bones of the leg, for example, may be palpated as easily from behind as from in front. This is, of course, an extreme and late result but it illustrates the factors operative. Such abuses from neglect can be avoided by the proper use of massage. The evidence of the influence of massage is not limited to the locomotor system but may show itself systemically, equally graphically, in terms of an improved color, sharpened appetite, better sleep, greater contentment with confinement to bed and a general sense of well-being.

The use of massage is important also as a contribution to the maintenance of health in the elderly. As such persons become less able to take exercise and of necessity lead more sedentary lives, they lose many of the benefits incidental to bodily activity. Massage offers a partial substitute for such activity. Elderly persons should never enter on a course of massage except at proper hands and with great conservatism; but many executives in their later years, who carry large responsibilities, have found that massage, in conjunction with suitable periods of rest and mild forms of activity, enables them to maintain themselves at a higher level of efficiency. Laplace and Nicholson have recently adduced evidence that in elderly persons confined to bed, the resulting inactivity may be a direct cause of death.[5]

Whatever the purposes of systemic massage, whether for a specific disease or for more general ends, it must always be followed, as elsewhere pointed out, by an adequate period of rest, generally about an hour. A point which requires great emphasis is the fact that systemic massage makes demands on the intangible reserves of the body such that depletion may result if the massage is combined with other forms of active therapeusis. The mistake is commonly made of sub-

5. Laplace, L. B., and Nicholson, J. T.: Prolonged Recumbency as a Contributory Cause of Death in Elderly Persons, J. A. M. A. **110**: 247 (Jan. 22) 1938.

jecting persons to massage in addition to such measures as sweating, the removal of focal infections, the use of vaccines and the like with the net result that the sum total of therapeutic activity taxes the individual as a whole beyond his capacity to respond in respect to any of the measures applied. The end-result of such overtreatment is therefore not only failure of benefit but positive detriment in the way of fatigue, nervousness and even exacerbation of the original complaint. The importance of preserving a balance between the various forms of physical therapy applied on the one hand, and the capacity of the individual to yield the response desired, on the other, must never be forgotten.

A fundamental consideration is that tissues of all kinds require a certain minimum of rest for reparative processes. It is common knowledge that the broken leg requires continued approximation of the fragments until the repair, which means union, is achieved. It is commonly overlooked, though equally true in principle, that protoplasm of whatever kind also demands opportunity for repair. In the field of physical therapy this usually means adequate care and rest not only of the parts concerned but also of the body as a whole.

THERAPEUTIC AND REMEDIAL EXERCISES

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It is my purpose to confine myself to the practical application of physical exercise as related to the health of the human body rather than to discuss problems involved in the physiology of exercise.[1]

Almost all of the bodily movements done by a normal person throughout the day's routine, such as sitting, walking, eating and dressing, consist essentially of a successive recurrence of simple reflex acts. However, the matter of learning new movements has an entirely different significance and involves a review of the phenomenon of muscular control. It is interesting to syllogize on the subject of what happens when a boy learns to swim, a girl to knit or an athlete to pole vault. The answer is found in an understanding of the classification, action and coordination of muscles.

Skeletal muscles are classified as prime movers (protagonists or agonists), antagonists and synergists or fixers.

Prime movers (protagonists, agonists) are the muscles which actually produce an intended movement. The antagonists are those which tend to oppose the action of the prime movers. The synergists so modify the action of the first two that the intended movement is performed smoothly, free frcm shocks or jolts and with the least expenditure of energy. Without collaboration of these various groups the apparently simple act of bringing a glass of water to the mouth would indeed be awkward and conceivably impossible, much as the infant finds it difficult to convey a spoonful of food into his mouth.

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1. For studies on the physiology of exercise the reader is referred to Lipovetz (Applied Physiology of Exercise, Minneapolis, Burgess Publishing Company), who concisely interprets studies on the phenomenon of muscle contractions; the chemical changes of contraction; the phenomenon of muscular action, control and movement; equilibrium, postural tonus and tonus reflexes; nerve mechanism of the heart; innervation and chemistry of respiration, and the localization of brain function and the process of learning.

Still another motivating force which contributes smoothness and grace in the process of performing an active exercise is the process of relaxation. Whenever a group of muscles contract normally, the respective antagonists are made to relax at the same time. Thus, when the elbow flexors are made to contract, causing flexion of the elbow, the movement is accompanied by a relaxation of the normal muscle tone of the extensors. This is a positive and not a negative action, known as Sherrington's law of reciprocal innervation.

Muscular activity falls into two main divisions, active and passive. The raising of a patient's arm in abduction is an active movement if performed by the sole efforts of the patient himself; it is a passive movement if applied by the assistant to the patient without the latter offering any assistance or resistance. The active group is further subdivided into various minor groups.

Active, voluntary purposeful movements are initiated by mental processes. They affect the upper and lower neurons, the motor and sensory nerves, the myoneural junction and the muscle itself. Neither passive movements nor muscular action initiated by an electrical impulse can so exclusively and favorably influence the neuromuscular arc. This intricate mechanism is so complete that when the command for movement is given by the brain cells there is always a clear mental picture of the intended movement. For a movement impulse to express itself, it must be controlled by the sensory nerves, for the will and the sensibility are functions inseparably connected with each other. Because of this intimate relationship between brain and muscle, voluntary purposeful movements are of vital importance in restoring various nerve-muscle disturbances to normal.

Occupational therapy permits and may augment active exercise. Skills and crafts can be taught and learned by the use of hands and legs. In this manner function can be more quickly restored by the patient continually repeating the desired active movements. By this means the monotony of a routine gymnastic exercise is avoided by appealing to the creative instinct of the patient. Patients with little or no interest in life may be stimulated frequently to an entirely different outlook by this form of active exercise.

Passive movements are performed by an operator without the assistance or resistance of the patient. This action must not be confused with manipulation of a joint limited in motion due to fibrous adhesions of extracapsular or intracapsular origin. Neither should it be recognized as a synonym for the term relaxing movements, since passive movements are in no way concerned in releasing tension of muscular tissue. Passive is a descriptive term meaning the opposite of active. In passive movements the sensory association motor neuron synapse is in no way involved, whereas this unit is definitely and vitally concerned in the phenomenon of relaxation.

The significance of passive movement will be more fully appreciated by noting its practical application in physical medicine:

(*a*) To be used preliminary to active movement when the latter may be harmful; i. e., in the treatment of fractures or when active movements may be harmful or actually impossible.

(*b*) To improve the return lymph and blood circulation by virtue of compression and joint motion.

(*c*) To retain full amplitude of joint motion by the prevention of contractures, shortening of muscles and the formation of adhesions.

(*d*) To maintain conscious proprioception.

(*e*) To maintain nerve power by stimulation through stretching and shortening of muscles.

Resistive movements are those in the course of which the technician resists the efforts of the patient, or vice versa. The technician offers just as much resistance as the patient is able to overcome. In certain pathologic conditions these movements have distinct advantages over the active voluntary type of exercise.

(*a*) Single muscles or groups of muscles can be caused to function to an optimal degree because of a more complete relaxation of the prime movers and a consequent lessened resistance. This phenomenon is due to the operation of Sherrington's law of reciprocal innervation. The technician resists to a degree permitting the greatest range of motion [page 26 (*a*) resistive movements].

(*b*) By the same token protective spasm may be lessened. For example, resistance to knee flexion relaxes the overactive quadriceps.

(*c*) The work done by the muscles can be graduated to any amount desirable.

(*d*) By virtue of *a* and *c* resistive movements offer an excellent method of studying muscular action and relative strength.

Assistive movements, as the name implies, are useful in supplementing voluntary effort where normal muscle power is deficient. For example, a patient with a weak deltoid in the supine position is asked to bring the arm to a 90 degree abduction.

During the range of motion, assistance is offered by the technician for the first and third part of the movement while the patient alone performs during the second part.

Isometric muscular contraction currently has been unsatisfactorily termed "muscle setting." The muscle is contracted but does not involve joint action. It is admirably adapted to conditions of fracture or joint injury to arm or leg. Though the patient's leg may be encased in a plaster cast, still he is able to carry on muscular contractions, thus improving the circulation and the muscle tone.

AIDS IN MUSCLE TRAINING

In treating weak muscles by means of active exercise there is always a danger of overtaxing and causing exhaustion which would hinder the progress of the recovery. So as to minimize this danger it has been found helpful to employ certain procedures with an aim to lessen the factors of gravity and friction. I will mention those commonly employed, which in turn may suggest others to the reader:

(*a*) *Postural.*—The aim is to place the body in a favorable position, thereby eliminating gravity to a greater or lesser extent. For example, in treating a weak deltoid muscle the patient is placed on his back with the arm to the side resting on a smooth board covered with talcum powder. The arm may then be brought to a 90 degree angle, which the patient could not do in a standing position without a severe strain on the deltoid muscle. Similarly in treating a leg the heel may be placed on a roller skate, a piece of board with gliders underneath or a thin rubber sponge. The patient is now able to abduct and adduct the leg and flex the knee, gravity having been eliminated and friction having been reduced to a minimum.

(*b*) *Sling Suspension.*—Still another method is to suspend the extremity in a sling about 6 inches from the bed or table, thus removing the element of gravity. Again in this position the leg may be abducted and adducted and the knee flexed with comparative ease and without straining the muscles involved. In my experience I have found it helpful to attach to the lower end of the sling a 1 inch band of inner tubing, which gives opportunity for increased amplitude of motion. It also adds the element of resistance, which is desirable.

(*c*) *Underwater Exercises.*—These movements are performed in therapeutic pools or a tank constructed for home use.[2] Exercise in the pool must not be confused with swimming. It is useful because the buoyancy of the water lessens gravity and makes possible the application of therapeutic exercise.

(*d*) *Muscle Testing.*—In preparing a plan of muscle reeducation it becomes essential (*a*) to learn to what extent the muscles have been damaged in order to ascertain their capacity for work and (*b*) to keep in mind certain characteristic muscle reactions. As an aid to the former the following classification of muscles may be used or modified by giving each group a numerical value:

1. A normal muscle: patient can overcome gravity and resistance.
2. A good muscle: patient can overcome gravity and resistance, but less than normal.
3. A fair muscle: patient can overcome gravity only.
4. A poor muscle: patient can produce movement only with gravity eliminated.
5. A trace: contraction of muscle can be palpated but with only little or no motion.
6. Gone or total paralysis: no contraction felt.

Once the strength of a given group of muscles has been found and properly grouped, the selection and execution of correct remedial movements should be governed by well known principles of muscle action. A muscle group in need of strengthening should not be called on to perform its maximum load at the beginning of training; the capacity for work is greater if at no time the muscle is pushed to its limit; it is more desirable to exercise often for short periods rather than a few times for long periods.

Since it is of great importance to guard against exhaustion, special attention should be focused on the

2. The Council on Physical Medicine will send free directions for the construction of a tank. Handbook of Physical Medicine, American Medical Association, 535 North Dearborn Street, Chicago.

following precepts: Exercise may be carried to the point of fatigue, but not beyond; the greater the frequency of contraction, the more rapid the approach of fatigue; the more complete the exhaustion, mental or muscular, the longer the period necessary for recovery; and the more complex the discriminations required in a performance, the more rapid the onset of fatigue.

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BODY MECHANICS AND POSTURE

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Physical medicine is a more correct term than physical therapy when such a subject as body mechanics is included. By body mechanics is meant both the static and the functional relationship between the parts that make up the body, and the body as a whole. The study of body mechanics is of as much value in prevention as in the cure of pathologic conditions of the body. The White House Conference on Child Health and Protection made the guarded statement that "it is reasonable to believe that 75 per cent of the youth of the United States exhibits grades of body mechanics which are imperfect." In zoology and botany one finds more definite information of the relationship of appearance and function. Every one can recognize a sick dog because of the dejected position of his body, and all understand when a plant is failing because of its appearance. Every one in the great army who combats human ailments must be interested in the prevention as well as in the cure of disease. Therefore every one should have some knowledge of body mechanics, because it has its application in all specialties.

Body mechanics may be discussed under the following headings:

I. The relationship of posture to health.

II. Evolution of Posture. (The development of our present body, the anthropology of the various systems and the phylogenesis of their functions, which must be analyzed by body mechanics in its broad sense.)

III. Posture standards and treatment.

IV. Body mechanics in various specialties (orthopedics, pediatrics, obstetrics and gynecology, internal medicine).

I. RELATIONSHIP OF POSTURE TO HEALTH

Our body build is largely inherited, just as the shapes of our features. Our features cannot be changed, and neither can our body build. However, the interrelations of the 200 bones or more which are joined

together by ligaments and acted on by muscles are subject to the same mechanical laws and forces which control any other machine. The maintenance of body function, of health, of life itself is concerned with balance between antagonistic forces. Balance is the motivating force in good posture, if we lie down, walk, play baseball, ski or swim. When this balance is disturbed by fatigue, accidents, disease or occupation, the efficiency of the body as a machine is lowered. It may be said that physical laws applied to our body mechanics give the answer to the question if posture is related to physical health.

Even mental health is affected by posture. Our sense of well-being and our emotions are often mirrored in our posture. The psychologist William James once wrote that correct posture kept up the spirits and tended to banish fear and depressing thoughts. All artists, be their medium clay or oil, have always associated alertness with good posture and depression with a slouch.

There are many clinical evidences for the effect of poor body mechanics and health. It is true that we all know of persons with poor body mechanics enjoying apparently perfect health. It must be remembered that our body is wonderfully adjusted to compensate for partial deficiency and also that many persons are satisfied with second or third degree health. The medical profession was slow in accepting poor posture and poor health as one of cause and effect. In 1740 Nicholas Audry taught that many illnesses in children had their origin in imperfect body mechanics. A generation ago the foundation for our present conception of body mechanics and health was brought out by Goldthwait and continued by Osgood. All surveys of posture in our primary schools show less illness, as proved by absences among children taught good body mechanics. Similar surveys in our colleges indicate a definite correlation between good functional health and good body mechanics.

Internists report improvements in arthritic patients when their body mechanics is corrected.

Miller and Polak have shown a definite relationship between posture and health in patients with dysmenorrhea and backache.

Orthopedic surgeons have overwhelming evidence for the importance of body mechanics both as a preventive and as a curative agent. Foot strain, knee pain, backache and many other complaints come daily under their observation and may be eliminated or improved by correction of body mechanics.

II. EVOLUTION OF POSTURE

Comparative anatomy teaches much about the assumption of the erect posture, and to understand body mechanics, one has to consider the alterations that the human anatomy underwent when the body was changed from quadruped to biped. This alteration in posture caused very definite changes not only in the shape and actions of bones and muscles but also in the workings of the circulatory, digestive, endocrine and nervous systems. Further analysis disclosed changes in the histologic structure of the tissues and in the chemistry of the body.

(*a*) *The Skeleton.*—When strolling through a museum of natural history and viewing the skeletons of reptiles, birds, dogs, anthropoid apes and man one can easily visualize what kind of locomotion such a skeleton performed. The reptile's skeleton was made for swimming and crawling. The forelimbs were developed to raise the animal off the ground and into the air. The hind legs were developed together with the foreleg, and there was the quadruped. The anthropoid apes began climbing trees and holding the body erect at intervals, at least, and man represents the highest development in biped skeletons. The spine changes little, but the head and extremities show pronounced changes. The skull becomes bigger and heavier, especially the frontal and parietal bones. This heavier head is balanced on the cervical spine with the convexity forward. The scapulas are displaced downward, giving a longer neck with more mobility, which compensates for the fact that the eyes are directed forward. The keynote of construction in the shoulder and upper extremity is mobility and speed rather than support. The human clavicle is long in order to hold the shoulder girdle away from the sternum. Thereby the clavicle becomes parallel to the posterior ribs rather than to the lateral ribs as in the quadruped. The glenoid fossa is small, allowing free movement of the humerus, and this movement is restricted and protected by the

acromial process. The so-called carrying angle at the elbow, the slightly separated bones in the wrist and the separation of the thumb from the other fingers are characteristic of the human skeleton.

The biped thorax has its greatest diameter from side to side, with a wide costal angle. The first rib is almost horizontal, and the last rib is nearly vertical and may produce periosteal irritation with the transverse process of the vertebrae.

The spinal column, originally intended for swimming and crawling, presented a convexity posteriorly. The baby is born with a one curve spine, but when it can raise its head the cervical curve develops, and when it can stand the lumbar curve is formed. The sacral and coccygeal vertebrae help to reinforce the pelvis. The spine, with its strong vertebral bodies, its numerous processes and the intervertebral cushion-like disks, is a marvel of elasticity and strength. There are many variations of the spine, both as to number of vertebrae and as to degrees of the curves. They may be regarded as evolutionary progression or retrogression. Thus a lumbar spine of four vertebrae may be considered as a progression and the one curve spine in spondylitis as a retrogression. The force of gravity, transmitted through the spine, is received by the sacrum at an angle. The anterior surface of the sacrum is broader than the posterior surface, and therefore a certain amount of anterior-posterior motion is possible. However, any displacement between sacrum and iliac bone is questionable. The lumbosacral articulation is more commonly involved in pathologic conditions of the lower part of the back. Here a freely movable spine meets a rather rigid pelvic girdle. In the quadruped the sacrum and the ilium are long, narrow bones, while in the biped there are broad, flaring sacrum and iliac bones. These, together with ischial and pubic bones, support the viscera above, protect the reproductive organs within and serve as muscular attachment for the powerful walking muscles. A plane laid through the symphysis pubis and posterior superior iliac spine is at about 40 degrees with the vertical frontal plane and at about 50 degrees with the horizontal plane. The analyses of these planes are important when dealing with body mechanics, because the pelvis works as a double lever with the fulcrum in the hip joint, and

any changes in these planes have an important bearing on the position of the spine.

The angle of the neck of the femur is depressed from 150 degrees in the quadruped to 125 degrees in adult man. The head and neck are rotated forward, so that on standing most of the head looks forward. The femur is bowed forward in man, and it was from the study of the histologic construction of the femur that Wolff evolved his law of functional adaptation. Most quadruped knees are held in flexion, while the human weight bearing knee supports the body weight in extension. The medial condyle of the femur is more distal than the lateral one, which projects forward slightly. This projection prevents the slipping of the patella when the quadriceps contracts. The line of gravity falls slightly to the outside of the middle of the knee joint as the result of the valgity. This is even more pronounced in knock-knees, while in bow legs gravity falls toward the median side. Knock-knees are more prone to give trouble than bow legs and often show ligamentous strains and patellar deviations.

It might be suspected that the change to the erect posture would be pronounced in the foot, which is the point of contact between the skeleton put on end and the ground. This is the case. The tarsal and metatarsal bones are in closer apposition than are the corresponding quadruped bones. The development of the horizontal and transverse arches are seen. The big toe is held in extension and close to the other toes, which are held in flexion. The inverted foot of the tree-climbing ape is now everted, and the heel, the outer edge of the sole, the distal ends of the metatarsals and the entire hallux are developed for weight bearing purposes.

(*b*) *The Muscular System.*—The changes in the skeleton are mainly determined by muscles. The aforementioned skeletal changes are therefore to be considered in the light of trophic stimuli of function.

The quadruped holds up his head by means of a powerful ligamentum nuchae, which is aided by strong posterior neck muscles. In the human being the skull is delicately balanced on the cervical spine, the ligamentum nuchae is rudimentary and the neck muscles act like guy ropes. It is easy to understnad that if the human construction of head balancing is forced to hold

the head in the quadruped way an undue strain is put on the posterior neck muscles. This is what takes place when one sits in a slouching position with the chin touching the chest, and it will result in a myositis that is often encountered and not easily dealt with unless the position of the head is corrected.

The trapezius, the levator scapulae and the rhomboids help to hold the scapulas in place. When the shoulders are allowed to slide forward and down, pressure symptoms may develop from the cervicobrachial nerves and the blood vessels.

The development of the deltoid in man is related to the increased motion in the glenoid fossa. This has been obtained at the expense of power and stability. One recognizes this in the whole upper extremity. A phylogenic study of the upper extremities shows that abduction, external and internal rotation in the shoulder joint, supination and pronation in the forearm, and apposition of the thumb to the other fingers are more recent developments. It is also of interest to speculate on the fact that these phylogenically younger movements are the first ones lost and last ones regained in many pathologic conditions. These are probably examples of specific morbidity.

An analysis of the mechanics of the extensors and flexors of the wrist and fingers, and the supinators and pronators of the forearm, will give a better understanding of traumatic external epicondylitis and will produce better results in its prevention and treatment.

The most pronounced change in the hip, when the anthropoid is compared with man, is the development of the abductors and the extensors. The opposing adductors and flexors were stretched when the biped position was assumed. Certain check ligaments reinforce the hip joint, the strongest one being the Y ligament, which becomes taut in the erect position. The specific morbidity based on phylogenesis should produce a flexion-adduction deformity in the hip joint following injury and disease, and this is exactly what takes place, and the comparatively new motions of extension and abduction are lost.

The biped locomotion, with flexion-extension of hip and knee, requires a more specialized quadriceps muscle than is seen in the quadruped. This muscle is the keystone of good walking. The coordinated flexion in the hip and extension of the knee are made possible by the

union of the rectus femoris and the vastus medialis and lateralis into one tendon, which is kept taut by the vastus intermedius. Any atrophy or diminished tone of this important muscle, which frequently follows pathologic conditions of the femur, or the knee, should be counteracted as early as possible, or the convalescence will be a very long one.

The knee extension is checked by the hamstring muscles, gastrocnemii and the popliteal ligaments, which latter reinforce the capsule. Any motions but flexion and extension are prevented by the lateral ligaments, the external and internal menisci and the crucial ligaments. The continued sitting position often leads to shortened hamstrings and gastrocnemii. In biped walking the body weight must be lifted and the foot must push the body off the ground. For this purpose the plantar flexors of the toes and foot are well developed. The thirty-eight articulations of the foot, supported by numerous ligaments, the anterior-posterior and lateral arches, all activated by long, slender, quick action muscles and coordinated with movements in knee and hip, make the human gait a great advancement over the shuffling locomotion of the anthropoid ape. The everted human foot, held parallel to the ground by the peroneal muscles, is far different from the grasping inverted foot of the ape, which type of foot is, however, found in the newborn baby up to the age of walking. The extension and eversion of the foot are undoubtedly phylogenically younger movements, and these functions are usually the ones easily lost in paralysis and neuritis from alcohol or metallic poison.

(*c*) *The Gastrointestinal Tract.*—The spine being the main support of the viscera, it is evident that the change to an erect position will affect the organs concerned with the maintenance of nutrition. If several rings are held on a horizontal stick they will hang free from one another, but if the stick is brought to a vertical position the rings will crowd on one another at the lowest point. This is what takes place, to some extent, in the change from a quadruped to a biped posture.

The stomach is attached to the diaphragm at the cardia, and the pyloric end is fixed to the body wall. The liver is partly suspended from the diaphragm and the transverse colon indirectly by means of the meso-

colon. A great load is therefore carried by the center of the diaphragm, which, at least partially, is held through the right pericardium by the continuation of the cervical fascia. This fascia is attached to the cervical spine and mastoid process. One can understand, therefore, how flexion of the head and neck relaxes the cervical fascia, causing a ptosis of the viscera in the upper abdomen with pressure exerted on the organs in the lower abdomen and pelvis. Thus it is of importance to carry the chin in and the head back.

The stomach is usually placed well under the ribs of the left thorax. The upper part of the abdomen is roomy, but the lower part is very narrow because of the dorsal and lumbar curves of the spine, which give the maximum room above and the necessary support below. In fact, the anterior surface of the fifth lumbar vertebra is nearer to the anterior surface of the body than it is to the posterior surface.

The spaces flanking the vertebral bodies are filled with the psoas and quadratus lumborum muscles, which adds to the formation of a pear shaped abdominal cavity. The axis of this cavity to the perpendicular line is about 30 degrees. The pelvic cavity, which is directed down and back, has an axis which shows an inclination of about 60 degrees with the perpendicular line. Thus the two cavities are at right angles to each other, which, of course, counteracts the pressure downward. It is in this pear shaped abdominal cavity that the viscera are suspended.

The liver, spleen and kidneys rest on shelves reinforced by adipose tissue and suspended by fibrous bands. The small and large intestine are, in the main, suspended; the other viscera are shelved. In quadrupeds the whole large intestine has a mesocolon. The human ascending and descending colon is usually retroperitoneal and only the transverse colon has a mesocolon, which is suspended from the stomach. However, the quadruped mesocolon persists in about 30 per cent of human intestines, and this adds to the crowding of the viscera. It is evident that any deficiency in the suspension or in the shelves will produce a ptosis and will increase the kinks in the stomach as well as in the small and large intestine; these will have an unfavorable influence, in turn, on the digestion, assimilation and evacuation of the gastrointestinal tract. The con-

gestion that results in the lower abdomen and in the pelvis may add to the factors producing leukorrhea in the female and prostatitis in the male, as well as prolapse of the uterus and anus.

(*d*) *The Circulation.*—The experiment in which a rabbit, when held erect, died from hemorrhage into the splanchnic area suggested that the circulatory system must have undergone certain changes when the biped posture was assumed. In the quadruped body the heart forces the blood stream in horizontal arteries and downward into the extremities, and the only veins that must sustain the weight and pressure of a vertical column of blood are those of the extremities and the intercostal veins. Therefore these veins are provided with valves.

In the erect posture the circulation becomes vertical. One can easily comprehend the increased work that the biped position threw on the cardiac musculature when it is considered that much of our rest is taken in the sitting position, which does not materially alter the load of the vertical circulation on the heart. The valves remain in the intercostal veins, although they have become unnecessary. The lack of such valves in the portal vein may be one of the contributing factors in hemorrhoids, pelvic congestion and ascites.

In the erect position the top of the head is about 40 cm. above the level of the heart, whereas in the quadruped the highest point is only about 15 cm. above the heart. The 25 cm. difference in the blood column represents about one twenty-fifth of an atmosphere. This is a definite addition to the quadruped blood pressure in the left ventricle, and the human organism is as yet but imperfectly adapted to it.

In addition, the arterial pressure is increased by gravity in proportion to the depth below the level of the heart, a depth which varies in both biped and quadruped positions. The portal circulation in the quadruped is at practically the same level as the heart. However, when the biped posture is assumed, the veins of the portal circulation lie 15 to 25 cm. below the heart level and the pressure in these blood vessels is suddenly raised from 15 to 25 mm. of mercury. On account of the high capillary pressure in man there is a greater tendency to edema of the dependent parts than in similarly constituted quadrupeds. This tendency applies especially to the portal area, where the integu-

ment is loose, there is double circulation and there is less capillary support.

(*e*) *The Nervous System.*—Although we have seen how the stimulation of muscular contraction affects the bone production, the question of how the osteoblasts rearrange their alinement and production can be answered only by scientific speculation, because of our limited knowledge of biochemical and electrothermic processes. However, it can be assumed that the nervous system plays some part in this trophic change because of the absence of functional response in cases of paralysis. It is therefore necessary to consider the changes into higher specialization of the nervous tissue which made the erect posture possible.

Judging by a child's first efforts to stand and walk, it seems that the erect posture was initially a very conscious effort and that it became less so by force of habit. To keep the skeleton on end in addition to all the other fields of activity thrust on the nervous system in the biped posture required an enormous increase in the size and specialization of this system.

For our purpose, the nervous system may be studied in relation to balance and muscle tonus. Balance is maintained by vision, the semicircular canals, the cerebrum, the cerebellum, and the deep-muscle sense, and deficiency in any one of these will stimulate the remaining ones to increased activity. This accounts for the superior muscle sense of the blind and is the basis of Frankel's treatment of locomotor ataxia.

By muscle tonus is meant the slight persistent tension which is characteristic of a healthy muscle. This tonicity is of the greatest importance in the maintenance of good body mechanics. Our knowledge of muscle tonus is rather limited, but it can be safely stated that the brain and the spinal cord, as well as the impulses arising in the muscles themselves, take part in the control, production and maintenance of the muscle tonus.

The brain's share in maintaining the erect posture may be deduced from the fact that mental concentration is more likely to produce correct posture than the lethargic state of the mentally deficient, among whom the quadruped posture is approached.

Experimental physiology demonstrates that a spinal frog, when suspended, will not take the attitude that

gravity would impress on it. If one hind limb is extended gently it will soon draw up and resume the familiar crouching position. This posture of the limb is therefore the result of impressions continually ascending its proprioceptive nerves and exciting a tonic activity, which predominates in certain definite muscles. These posture reflexes, as carried out by the spinal cord, are segmental responses. They determine the relation of the limb to the trunk and, to a lesser degree, of the four limbs to one another. Experiments by Sherrington show that they are reflex in nature and are confined to the so-called antigravity muscles, which maintain the erect posture.

There is no doubt that some primitive posture reflexes are retained in man. We may even assume two posture centers, one in the upper cervical region and the other in the lumbar region. If the patient sits in a relaxed position, throwing the head back in extreme extension of the cervical spine, and from this attitude flexes the head forward so that the chin is pulled in, the result will be that the upper part of the body will assume the correct posture; that is, the back will straighten out, the thorax will be elevated and the scapulas will slide back and down where they belong. It is also of interest to note the postural reflex in the lumbosacral region. If a patient, lying face down, is asked to extend one of the lower extremities with the knee straight, a slight internal rotation of the extremity as a whole will result, with the foot in inversion. These two postural reflexes are of importance in the treatment of faulty body mechanics.

There is another side to posture reflexes, which has been studied by Magnus and de Klein. This deals with plants as well as with animals and their growth in relation to the environment. These investigators have shown that plants orient themselves in regard to gravity along well defined laws. This orientation is called "geotropism" and these same geotropic reflexes, or righting reflexes, are responsible for the ability that animals have to restore themselves in erectness. The phenomenon of a cat always alighting on its feet when tossed in the air is a well known example of this righting reflex.

Thus, in the final analysis of posture one arrives at the postural tone, which Sherrington has defined as

"the reactions in which the configuration of the body and its parts is preserved, in spite of forces tending to disturb them, by the activity of contractile tissues, these tissues then functioning statically." This is the basis of physical education, the fundamental truth of which has been forgotten in the search for new and sensational systems.

(*f*) *The Endocrine System.*—Closely associated with the nervous control of body mechanics are the endocrine organs. Study of pathologic conditions of the pituitary gland leads to the deduction that there is some control by this gland over the growth of bones. The pituitary disease called acromegaly, in which the response of the osseous tissue to external stimuli is much increased, forms a beautiful example of Wolff's law. The voluntarily most active parts of the body are the lower jaw, the hands and the feet, and these parts are much overdeveloped in patients suffering from acromegaly.

From similar observations it is known that the overactivity of the thyroid gland produces a slender body type and that diminished activity of the thyroid produces the stocky type of myxedema. The same considerations apply to the thymus, ovaries and testis, all of which, to a certain extent, determine growth and nutrition.

III. POSTURE STANDARDS AND TREATMENT

The human body cannot be standardized, and individuals therefore cannot be made to conform to any definite preconceived standard physically, mentally or spiritually. Two contrasting body types must be recognized. There is the slender, high strung body build, often referred to as the carnivorous type. The other extreme is the stocky, placid type, also known as the herbivorous type. In between are all grades of variation. The posture standards illustrated here can be obtained from the Children's Bureau, Department of Labor, Washington, D. C. Although photographs and x-rays are valuable, they are not always practical. The physical examination should note the following:

1. Drop a tape measure from the mastoid process over the acromial process; it should hang over the greater trochanter and external malleolus. Also drop a tape measure from the posterior process of the seventh cervical vertebra; it should hang midway between the buttocks, the knees and the malleolii.

2. With the patient placed with his back to the wall and the feet 1 inch away, there should be only slight curves in the cervical, dorsal and lumbar regions. The chin should be pulled in over the sternal notch. The sternum should be the farthest forward part of the body, with the costal angle wide. The lower abdomen should be flat. The lower extremities should be properly alined with the pelvis and the trunk. The femur and tibia should be perfectly opposed in the knee and this maintained by proper muscle balance, favorable to the weight bearing lines which protect the joint mechanism of the feet.

3. The body in motion must also be examined. Let the patient walk about the room and also jump on the right and left foot alternately. This will give an idea of the patient's motor habits.

TREATMENT

The causes of poor body mechanics may be considered under overactivity, insufficient or improper food, weakness against gravity and inherited or acquired faulty positions or movements.

Overactivity.—The rational treatment of overwork is, of course, rest. Hugh Owen Thomas said, many years ago, "The urging need of our art is the fact that much of our surgery is too mechanical, our medical practice too chemical, and there is a hankering to interfere, which thwarts the inherent tendency to recovery possessed by all persons not actually dying." Complete rest position should be approached as much as practically possible. This can be accomplished only on a hard mattress, with no pillow or a very small one. A small pillow under the knees will relax the iliopsoas and produce the anatomic rest position in the lower back, hips and knees. This position will rest the balancing mechanism, which means that the nervous and muscular systems cease working at high speed and have a chance to recuperate. The circulation becomes horizontal, with less demand on the heart and blood pressure. Gastrointestinal distress is often relieved by the recumbent position, respiration is easier and slower, and there is less strain on ligaments and cartilages.

Diet.—The quantity and quality of the food intake correspond to the fuel fed to a machine. We cannot expect function of the body unless properly supplied with carbohydrates for energy, protein for repair, and fat for insulation, minerals, vitamins and so on. The mechanical efficiency of the human body corresponds very well with a machine. In untrained men it is about

20 per cent, in trained men 25 per cent, and in outstanding athletes 33 to 41 per cent.

Support.—Constitutional weakness due to many causes, such as exhausting disease, operation, occupation and environment, often needs support. This support is often necessary in the interim between rest therapy and following the period of exercises. The shoulders may have to be held in a corrected position or the arches raised by means of adequate and inoffensive mechanical apparatus. However, it must be remembered that any kind of support is only a temporary remedy, except in the very aged, and should be discarded as soon as the muscles have regained their tone.

Postural Exercises.—Therapeutics in any field of medicine must be directed against the cause in order to be successful. If this is remembered when one is dealing with faulty body mechanics, it must be realized that exercises are not always the answer to poor posture. However, when exercises are indicated, they must be picked with discrimination. It must be realized that every effort to change voluntarily the relative position of the parts of the body is made through the use of the motor habits, which are expressed in the body alinement. To change posture, motor habits must first be changed in the motor pathways in the nervous system. With this change a different muscular response, both for balance and for movement, will occur. This is best accomplished by slow and oft repeated movements and the visualization of stabilized relationships of the various parts of the body during movement. The principle of posture exercises is best expressed by Cochrane: "If proper posture be maintained by conscious effort for a short time, then the increase of reflex tonus obtained by such posture will serve to maintain the proper attitude without the patient's requiring to give the matter thought and attention." The earlier such posture teaching occurs, the better, since age intensifies muscular habits.

BODY MECHANICS AT DIFFERENT AGES

Preschool Age.—This includes infancy to beginning school age. The baby's parents should be instructed in the symmetrical and nondeforming positions of recumbency as well as in the proper positions of hold-

ing the baby. Careful examinations of the baby's head following moving objects, of the grasping reflex of the hands, the kicking reflex of the lower extremities, the efforts at sitting, creeping and standing, will disclose possible abnormalities in growth and function. Some educators maintain that we waste five years of our lives being housebroken when much instruction could be given the child. Be that as it may, it seems only rational to watch this age group for tendencies to faulty body mechanics present in the parents and institute preventive measures. The type of exercises recommended are based on the primitive posture reflexes as advanced by Dr. Haynes. These postural reflexes were developed in the central nervous system before the frontal lobe of the cerebrum learned to think for man. They are the accumulation of associated movements.

Body Mechanics in Children of 5 to 12.—This is the age in which posture consciousness should be taught. However, it should not be associated with punishment. Instead, one should make use of plays and games so that the child will think of good posture with pleasure rather than with penal apathy. With girls, good body mechanics should be discussed in relation to dancing or the proper wearing of clothes. With boys, it is best taught in relation to sports. It is easy to bring out good body mechanics and to correct postural defects when describing the proper use of the body in baseball, swimming, skating and other activities. By combining postural correction with activities, the abnormal stiffness that our forefathers associated with correct posture is avoided and the easy, relaxed carriage is produced. Whenever possible, the natural posture reflexes should be the basis for the postural exercises in this age group. Corrective positions during rest periods are also recommended.

Body Mechanics in Adolescence (second decade).—In this age group body mechanics should be taught in relation to health. The school physician, the school nurse and the biology teacher should be included with the gymnasium teacher in the posture program. Efficiency in athletics should be emphasized in its relation to good body mechanics. A certain amount of corrective training should be introduced, based on hygiene, prevention of future defects and efficiency. There is no

reason why such postural habits should not be part of the adolescent life the same as the care of the teeth and the skin, which has been generally accepted.

Body Mechanics in Adult Life.—In this age group we encountered forces of occupation that may alter our body mechanics. It is wise to analyze possible damage done to our body by inactivity at a desk, by monotonous movements repeated throughout the day, and by faulty positions maintained in relation to machines or other unnatural static or dynamic functions that are imposed on civilized man. It is most important to counteract possible postural, occupational defects by exercises or games which will bring into use such parts of the body as are inactive or stretched during occupation.

IV. BODY MECHANICS IN VARIOUS SPECIALTIES

(*a*) BODY MECHANICS IN ORTHOPEDICS

No specialty comes in closer contact with body mechanics than orthopedics. I will mention only a few:

In congenital torticollis that has persisted for several years the child gets into the habit of photographing his surroundings on a certain field of the retina. The consciousness of such pictures is related to the child's appreciation of his position to his surroundings. Geotropic reflexes are built up which give the child the impression of being straight when his head is actually crooked, and vice versa. Therefore the cutting of the shortened sternocleidomastoid muscle and the shortened cervical fascia is only the beginning of the treatment. The patient's motor habits, based on the photograph of the surroundings on the retina and its interpretation, must be reeducated. This is a refined point in body mechanics that is most important.

The lateral curvature of the spine of the idiopathic type should be treated as a postural deformity, and symmetrical exercises should be instituted and carried on till the patient reaches at least his sixteenth year. Special attention to the patient's general health, as indicated by his vital capacity, is most important.

The use of postural exercises in low back pain has been confused a great deal. The confusion is due to the fact that the same exercises have been prescribed for all pathologic conditions in the lower part of the back. It should be emphasized that the exercises should be specific and should be based on the pathologic changes

present. Dealings with low back patients are facilitated by the following clinical classification:

Group 1.—A more or less severe tear may occur, producing a hemorrhage and muscle spasm. The muscles most involved are the quadratus lumborum, gluteus maximus and gluteus medius. A myositis is produced, by laymen called lumbago. The exercises should be preceded by relaxation and the movements should consist of gentle, rhythmic changes of position of the spine, often repeated, but without great effort.

Group 2.—There is instability of the lumbosacral region due to congenital defects, an increased lumbosacral angle, spondylolisthesis and other mechanical weaknesses of the fifth lumbar region. Here an attempt should be made to strengthen nature's corset, represented by the abdominal muscles and the gluteal muscles, and correct the posture relation between the pelvis and the spine. A typical exercise is the pelvic roll.

Group 3.—Any muscle imbalance in one part of the body will result in compensating imbalance in other parts. A pronated foot, short heel cord, contracted hamstrings or spasm of the tensor fasciae and erector spinae are examples. This requires careful analysis of the body mechanics. The exercises should stretch the shortened muscles, and their antagonists should have concentric movements.

Group 4.—This group includes the arthritic spine, by far the most common pathologic condition in the middle and old age group of patients. Included here are synovitis, or arthritis of the small joints of the spine, and also fibrositis along the spine. In the early stages of these conditions it seems rational to try to prevent freezing of the joint motions. This is done by active and passive separation of the articulations. Traction on the spine, flexion forward and sideways, but especially extension, lying, sitting and standing as tall as possible, are the principles used.

Group 5.—Here may be gathered such specific cases as fractures and subluxations, synovitis of the sacroiliac joints and rupture of the nucleus pulposus. In this group the treatment is usually specific, but exercises are often used in the convalescent stage and for symptomatic relief. Attention to the general body mechanics

should be observed. The proper alinement of the various segments of the body should be checked and possible spasm and muscle shortening counteracted.

(*b*) BODY MECHANICS IN PEDIATRICS

Pediatricians are usually concerned with children's diet, heart and lungs, tonsils and the infectious diseases of childhood. Body mechanics is seldom considered. The more importance laid on prevention, the more the responsibility is laid on the physicians who guide the child through the early life. Modern civilization has imposed many hardships on the human being, and a child's activities suffer more than an adult's activities. The child has less resistance. Let us, therefore, be kind and understanding, instead of nagging and punishing when we analyze defects in our children. The cause of the child's poor posture should be carefully diagnosed. It may be poor eyesight, poor nutrition or fatigue from various causes, such as constitutional disease or overactivity. There might be inherited weakness. It is evident that the treatment should vary. Exercises are not always indicated. However, when exercises are indicated they should be made a pleasure for the child and not an ordeal. The postural examination should be included in the physical examination and the following facts should be realized:

The feet are the foundation for weight bearing in standing and walking, and any defect in them will influence the rest of the body. If the feet are the foundation and the legs the supporting structures for the pelvis, we have the same mechanics as that of a bridge. The load of transportation varies, and stresses and strains must be met. The load that this bridge carries is represented by the trunk, which is held upright by the spine. In order to support the spine firmly, the pelvis should be placed in good mechanical relation to the spine. The spine, shoulders and arms can be likened to a coat rack, of which the main stem is the spine, the transverse hangers are the shoulders and the hanging coats correspond to the arms. If the spine is correct, the shoulders and arms will fall into the proper position. The head should rest with ease on the spine. This mechanical posture of the skeleton is maintained by muscles, which receive their tone from the nervous system, which in turn depends on the glands and the general nutrition and health of the body.

(c) BODY MECHANICS IN OBSTETRICS AND GYNECOLOGY

The specialties of obstetrics and gynecology seem far from the interest of body mechanics. However, statistics show that of 1,000 cases coming to a gynecologic clinic with the complaint of backache only 18 per cent were due to gynecologic disease and 82 per cent were postural in origin.

Dr. C. I. Miller of the State University of Iowa College of Medicine has published a study of young women in relation to dysmenorrhea. Among young women with dysmenorrhea he found 21.7 per cent with good posture and 78.3 per cent with poor posture. In the group without dysmenorrhea, 73.9 per cent had good posture and 26 per cent had poor body mechanics.

It is only rational to believe that the great strain put on body mechanics in the pregnant woman should merit more careful consideration. The center of gravity is altered during pregnancy, greater strain is put on the weight bearing extremities, physical activities are restricted, muscles are overstretched, the nutrition is unbalanced, and most of the body systems are put to severe tests. Therefore more thought should be given to the reconstruction of the delivered mother. It seems perfectly logical that child bearing should be carried out without permanent deformity to the body by prescribing postural corrections at the earliest date that these can be taken without danger of hemorrhage or fatigue. Special care should be taken to insure return of normal tone to abdominal muscles, and proper weight bearing of pelvis and spine.

(d) BODY MECHANICS IN MEDICINE

The internist has been slow in accepting the place of body mechanics in his armamentarium of cures.

However, overwhelming evidence has been presented by Pemberton, Swain and others that the arthritic patient must be taught the proper use of his body as a whole as well as the various joints. Chronically ill patients may be much improved by instruction in body mechanics. Many can be helped by special substitution movements or mass movement exercises.

Visceroptosis has received much attention from the point of view of body mechanics. Rest, support, diet and the proper instruction in posture and proper

postural function are generally accepted now as the foundation for the management of these patients.

Much of our training of spastic hemiplegia depends on the application of body mechanics.

Brachial neuritis, the scalenus anticus syndrome or the cervical rib syndrome are often postural in origin and can be relieved by correcting the position of spine, head and scapulas.

CONCLUSION

Body mechanics, or posture, assumes a greater importance and a wider application when viewed in the light of the foreging discussion. Certain conclusions also may be drawn:

1. The relation between health and body mechanics is soundly based on physical laws and on physiology. There is increasingly strong clinical evidence of posture and health being the cause and effect in many conditions.

2. The physician must be trained in the anthropology and phylogenesis of anatomy and function, so that he can analyze mechanical defects and prescribe proper treatment.

3. The question of posture standards is not satisfactorily solved, but a certain amount of literature can be obtained from the Children's Bureau, Department of Labor, Washington, D. C.

4. There is a definite need of more interest and more understanding of body mechanics among pediatricians, school physicians, gynecologists and internists.

Humiliating statistics were revealed by the universal draft in World War I, and it will be interesting to see if our present physical examinations for the draft will show any improvement. It is a pleasure to testify to the fact that our men in the armed forces today show the carriage and alertness of efficiency after even a short training period.

OCCUPATIONAL THERAPY IN A PRIVATE GENERAL HOSPITAL

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Occupational therapy is an objective treatment prescribed by a physician to hasten a patient's recovery from disease or injury or to contribute to his adjustment to hospitalization.[1] The activities used as treatment must be sufficiently interesting to the patient to motivate his active participation. The occupational therapist must be trained professionally to carry out the physician's prescription to select and adapt activities which meet the patient's physical and psychologic needs. The occupational therapist should be a graduate of a school approved by the Council on Medical Education and Hospitals and registered by the American Occupational Association.

Occupational therapy is divided roughly into the following groups:

1. *Preventive or Diversional Therapy.*—This type of occupational therapy comprises simple prescribed activities, including recreation, which serves to induce rest, to control general exercise, to prevent neuroses and to sustain morale.

2. *Functional Therapy.*—This type comprises prescribed activities planned to assist in the restoration of articular and muscular function, to improve the general condition, to build physical endurance and to aid in mental rehabilitation and in the treatment of mental disorders. Aitken[2] has shown the value of functional occupational and physical therapy in the rehabilitation of the industrial casualty.

3. *Prevocational Therapy.*—This type comprises work processes planned and prescribed to prepare a patient for his return to his former employment or for vocational education.

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1. Manual of Occupational Therapy, Chicago, American Medical Association, 1943.

2. Aitken, A. P.: The Rehabilitation Center, Rhode Island M. J. **26**: 286 (Dec.) 1943; Rehabilitation of the Industrial Casualty, Virginia M. Month. **71**: 177 (April) 1944.

Most large general hospitals maintained by county, state or federal funds have an occupational therapy department. A statement concerning the coordination of the physical and occupational therapy departments by Watkins [3] emphasizes that the combined departments should be directed by a physician specializing in physical medicine. The technical personnel in his department consist of a supervisor of physical therapy with six assistants, and a supervisor of occupational therapy assisted by two full time and one half time occupational therapists.

It is believed that every general hospital regardless of size should have an occupational therapy department, because it is as necessary as a physical therapy department and any other therapy. The occupational therapy department should be in the department of physical medicine and under the supervision of a physician specializing in physical medicine. Most private general hospitals will soon require a department of physical medicine (physical and occupational therapy) in order to carry out the federal-state programs for crippled children, the federal-state programs of physical and vocational rehabilitation and to enable them to care properly for many casualties of civilian industry.

Some insurance companies have begun to establish physical and occupational therapy departments as curative workshops or rehabilitation centers, as units separated entirely from hospitals. The advantage of this plan is that the patient does not feel that he is returning to the hospital for treatment, but the one disadvantage of the plan is that the doctor who originally treated the patient does not see him often. Lieut. Col. Raymond Hussey, M. C., U. S. Army, formerly chairman of the Board of Occupational Diseases, Department of Labor, and chairman of the committee on Workmen's Compensation, Council on Industrial Health of the American Medical Association, states "It is unfortunate, I think, that physical and occupational therapy clinics are organized separately from hospitals, since we all realize that physical and vocational rehabilitation procedures should be given simultaneously with medical and surgical treatment."

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3. Watkins, A.: Occupational Therapy and Rehabilitation **22**: 115 (June) 1943.

Recently an insurance company writing workmen's compensation insurance established a rehabilitation center for cases requiring physical and occupational therapy. The president of the company stated that in some instances of extended convalescence his experience showed that there was a considerable amount of difficulty in the achievement of complete recovery and a working status. In order to determine a solution, the company established the Rehabilitation Center. After a year of operation this insurance company was convinced that efficient physical and occupational therapy, under medical guidance, supplies a satisfactory solution to this problem and that rehabilitation should be instituted as soon after injury as possible. This indicates that rehabilitation should be started in the hospital.

In the last three editions of the Handbook of Physical Therapy some activities of the occupational therapy department at St. Luke's Hospital in Chicago were described. St. Luke's is a general hospital containing 485 beds and supported by private endowments and contributions. In order to illustrate the financial arrangements of an occupational therapy department, St. Luke's Hospital can be cited as an example.

For twenty-five years no charge was made for occupational therapy, because it was classed as a necessary adjunct of hospital service. Two years ago the chief of the medical staff thought that, as occupational therapy was a method of treatment, a charge should be made. These charges are now $1 per treatment for occupational therapy alone. When occupational therapy is combined with physical therapy, a minimum charge for the first hour or major fraction thereof is 50 cents and each additional hour or major fraction thereof is 25 cents plus the charges for physical therapy treatments. It was as difficult to introduce this added fee for occupational therapy as it would have been to launch a new department. Nevertheless, almost $900 was received during the first year.

General hospitals should maintain capable occupational therapy departments that can practice preventive or diversional therapy. Without occupational therapy many patients are unable to make the necessary social and institutional adjustments so essential to their recovery. The majority of hospitals provide libraries and radios, and occupational therapy is as important.

The physical therapy and occupational therapy departments at St. Luke's Hospital are under the direction of a physician specializing in physical medicine. In the occupational therapy department are two registered occupational therapists, and usually there is one occupational therapy student who is receiving instruction in the practical phase of this work.

When occupational therapy is being carried out the posture assumed by the patient is most important, whether the patient is in bed or sitting in a chair. Wherever possible, the occupational therapists should see that the following instructions are observed:

Prone Position: This position relieves the bedridden patient and may be adopted during a half hour of the rest period. A pillow is placed under the chest, and the arms are placed at right angles to the body, with the elbows flexed and resting on the mattress. A pillow under the lower leg assists in maintaining slight flexion of the knee and prevents a drop foot position. Sandbags may be necessary to prevent rotation of the hips.

Positions in Bed.—Recumbent Position: This position serves to prevent deformity and to improve general circulation. The following instructions should be observed:

Make the mattress flat. Boards as a rule should be put under the mattress.

Preferably eliminate a pillow under the head. A flat chest and slowing up of the circulation result if a pillow is used.

Place a small pillow or roll under the head of the tibia. Subluxation of the knee frequently results from a pillow under the thigh.

Train the patient to lie with his elbows and wrists extended to prevent flexion deformities. The arthritic patient frequently assumes a position in which he flexes elbows and wrists and rests them on his chest for comfort and body warmth. The pressure of the arms on the chest retards full inspiration and slows up circulation.

Prevent outward or inward rotation deformity of hips by propping the legs in position with pillows or sandbags.

Maintain a 90 degree angle of the ankles and prevent foot drop by using a heavy box or bricks at the foot

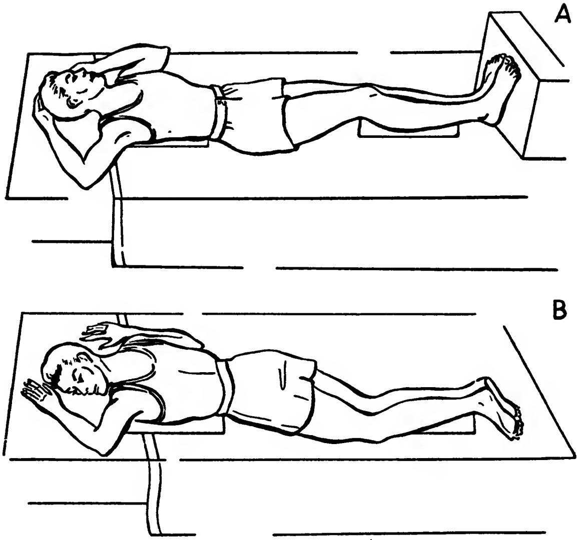


Fig. 1.—Positions assumed in bed by the arthritic patient to obtain physiologic rest. *A,* the supine position. *B,* the prone position.

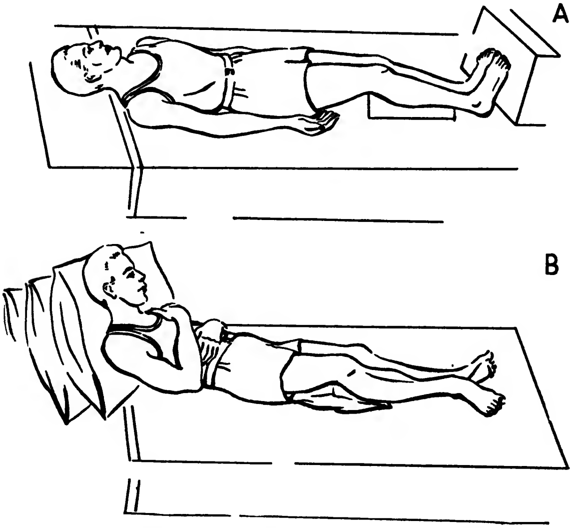


Fig. 2.—The recumbent position assumed in bed by the arthritic patient to prevent deformity and to improve general circulation. *A,* good position. *B,* poor position.

of the bed to hold the feet at right angle and prevent pressure of the bed clothes.

The occupational therapist should plan her equipment so that the patient who must lie flat on his back may maintain the good functional position which is illustrated (fig. 2 *A*).

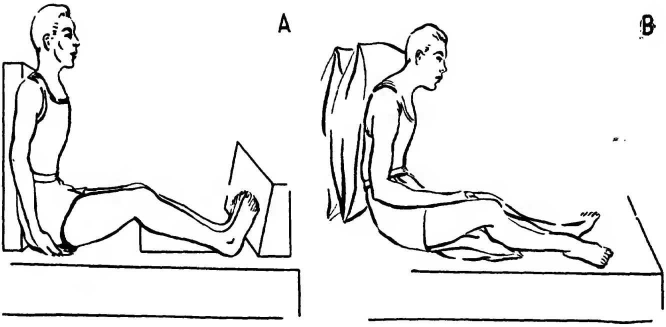
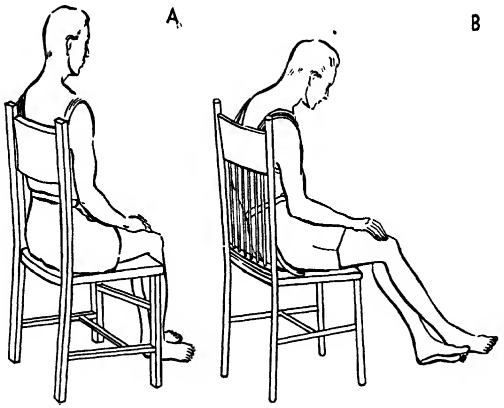


Fig. 3.—The functional position assumed by the arthritic patient sitting up in bed for occupational therapy. *A,* good position. *B,* poor position.



4. The sitting position assumed in a suitable chair by the arthritic patient. *A,* good position in a well selected chair. *B,* poor position in a badly selected chair.

Sitting Position: Use a flat canvas or board back rest if possible. If a pillow is used it should be firm and extend from the hips to the shoulders. The chin should be in, the head back and the chest high. A firm pillow or roll under the head of the tibia to flex the hip

and knee will prevent the patient from slipping down in bed and assuming a poor position.

The patient who may sit up for his occupational therapy should be in the good functional position illustrated in figure 3 *A* rather than in a poor functional position.

Position in a Chair.—Whether a wheel chair or a regular chair is employed, it should have a straight back. While sitting up the patient should be erect with chin in and chest high. If a pillow is used, it should be below the shoulders so the head is not pushed forward and the chest flattened. The occupational therapist should see that the patient is seated correctly at work.

Guide in Selection of Posture Chairs.—Support at the scapulas is essential. There should be a space between the top of the chair and the seat, so that the patient sits back in the chair. Slats, as shown in the illustration of bad seating (fig. 4 *B*), press against the pelvis, causing rotation and poor posture.

MENTAL DISEASES

Although St. Luke's Hospital is a general hospital, it has one floor for mental diseases. Here the occupational therapy department has one room (locked when not in use) devoted to these cases. Occupational therapy treatment is given in accordance with the principles of McGraw and Conrad.[4]

In the handling of neuroses the department utilizes occupational therapy as an aid in overcoming the tendency to avoid responsibility, in increasing the feeling of potency, in directing the desire for approval that is characteristic of the hysterical into more useful channels and in the allaying of the restlessness of anxiety.

If the occupational therapist is tactful, manic patients with agitated depressions may be persuaded to work quietly and to confess later that they have begun to feel more normal when thus occupied. The warning that cannot be too often stressed is that suicidal attempts come, not at the period of greatest inertia, but just at

4. McGraw, R. B., and Conrad A., quoted by Backmeyer, A. C., and Hartman, G.: The Hospital in Modern Society, New York, Commonwealth Fund, 1943.

the time when the patient is starting into or coming out of a depression, so that many patients who are just beginning to take an interest in occupational therapy may also be interested in using dangerous tools with great cunning and consequent menace to themselves. The same caution about tools is necessary when dealing with paranoid patients, but those institutions in which paranoids create a minimum of disturbance and are most contented are the institutions that have promptly provided a suitable occupation for each individual. If furnished with an outlet, the drive of these patients is much less violent; but the physician should be aware of an increase in tension among those who have long been permitted to use dangerous tools.

A helpful concept is to grasp the patient's interest at the emotional age level at which we find him living.

The problem in the acute phase of schizophrenia is not so much that of catching the attention of the patient as in maintaining his interest. We cannot be positive as to whether novelty or old habits should be relied on at this point. One patient with acute schizophrenia will be confused by unaccustomed procedures; another will block when old habits call up old conflicts. Not infrequently a woman having a paranoid precox will want to do carpentry or other work that she considers to be a man's occupation.

Generally a patient's expressed wishes to attempt any specific work is gratifying and well worth trying. Some occupational therapists may permit the patient to work out unconscious conflicts with symbolic objects, similar to the method which child psychologists use when they employ toys. This application is truly an analysis and requires all the safeguards of that technic. Dr. Conrad believes that in other than an exceptional case the major aim should be the progressive return of the individual to satisfaction and self confidence in participation in normal living. It is the responsibility of the physician to see that the procedure is adapted to the patient's individual problem.

A most delicate and often treacherous part of the treatment is in prescribing the work. It is rarely advisable for the physician to do this alone, and there are dangers in leaving it all to the therapist. Experience teaches us that correspondence to and fro is time

consuming and frequently unsatisfactory; nevertheless there should be some sort of joint action, and records should be kept.

In group treatment it is inevitable that various persons often compete for the credit of the cure and for the loyalty of the patient. We hear from nurses, from recreational aids and from occupational therapists "If I had more of a chance, I'm sure I could have accomplished so much more." Sometimes this is pure rationalization. Occasionally it is valid and might well be heeded at the risk of upsetting the routine a bit. The danger of presenting projects too simple for the highly intelligent, cultured and gifted patient should be borne in mind. This requires fine discrimination on the part of the technician and also an understanding of the background and personality of the patient. This information should be available in adequate record form for the therapist.

We are living in an age of specialization. Occupational therapy is a specialty and as such must bear the criticism as well as the praise due it. Some say that society, industry and medicine have all been overspecialized, and it is therefore somewhat of a paradox that the cry of "back to the patient" has been raised in the past decade. In opposition to the overspecialization is the precept "Treat the whole patient, not just his disease." Occupational therapy is much involved at this point.

Occupational therapy can help people find a better use of their leisure time. Illness and convalescence, even mental illness, such as neuroses and psychoses, provide a convenient opportunity to introduce this principle. Interest will develop in the creative arts and crafts and in craftmanship, and perhaps also in cooperation with others.

The "joint action" mentioned in this article is accomplished at St. Luke's Hospital by using requisitions which state diagnosis and occupational therapeutic precautions for each patient. These requisitions are made out and signed by the physician in charge of the case. They are supplemented by frequent visits of the psychiatrist to the occupational therapy department and by notes on the clinical record made by the occupational therapist.

The occupational therapist uses a great deal of recreational therapy through the monthly parties and dances for the patients, through games and through social activities.

Functional occupational therapy is usually given in a workshop, which, in a general hospital, should have large enough floor space to assist in the restoration of articular and muscular function in order to build up physical endurance and to aid in the whole physical and mental rehabilitation of physically handicapped patients. In these cases the coordination of the physical and occupational therapy departments is most important. St. Luke's Hospital is planning to enlarge the floor space of the occupational therapy department.

Rehabilitation is the planned attempt, through the use of all recognized measures under skilled direction, to restore those persons who, because of disabilities, do not assume to the greatest possible extent and at the earliest possible time that place in the productive stream of society of which they are potentially capable.[5] Rehabilitation of the injured must therefore start at the patient's bedside and must be continued during and after the patient's stay in the hospital.

Rehabilitation of the injured requires the cooperation of many services, such as surgery and psychiatry.

Often patients have a psychologic protracted convalescence, and it is therefore necessary to use psychotherapy. The Physical Medicine Department of St. Luke's Hospital employs Solomon's[6] method in these cases. It has four major divisions:

1. Psychologic understanding of the patient's character in order to avoid emotional trauma to his personality during all his professional and industrial contacts.

2. Psychiatric evaluation of the patient's emotional problems, both related and collateral to his accident, in order to clarify the dynamic meaning of his attitudes and make him understand his own behavior.

3. Careful supervision of all the psychologic aspects of his return to employment so as to avoid maladjustment and, if possible, improve his previous work adjustment.

4. Institute at the first evidence of psychologic protracted convalescence a recreational and exercise program.

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5. Minutes of Conference on Rehabilitation, Council on Rehabilitation, Philip D. Wilson, M.D., chairman, 321 West 42d Street, New York.

6. Solomon, A. P.: Rehabilitation of Patients with Psychologically Protracted Convalescence, Arch. Phys. Therapy **24**: 270 (May) 1943.

Griffiths [7] calls attention to several principles which should be observed in giving functional occupation therapy. He writes:

> The injured man must be divided into two categories. The cripple must have work to do from the outset so that he shall see that he still retains the ability to work. The recoverable must not have any treatment that remotely resembles his daily work, lest his pain or temporary clumsiness should instil in his mind fear for his ultimate recovery.

Prolonged exercise is often better obtained by exercises designed to interest the patient and to divert his attention from the particular group of muscles which we want to exercise. Griffith suggests:

> A choice of exercise is easily made which will achieve the desired movement in each patient without his being conscious that this exercise is deliberately designed to produce that movement. For example, if a group of patients contain one man in whom it is desired to strengthen the vastus internus muscle of the leg by repeatedly bracing the knee, a second in whom it is desired to hyperextend the spine, a third to flex the hip joint, a fourth to raise the arm at the shoulder, these men may be given the simple exercise of bouncing a rather soft football on the floor of a gymnasium hard enough to reach the ceiling. It will be found that, in spite of themselves, the desired movements will be attained time after time during the short period this exercise may be continued.

Functional occupational therapy in St. Luke's Hospital is used in orthopedic and surgical cases in such conditions as fractures, dislocations, strains, sprains, contractures due to burns, lacerations of tendons and peripheral nerve injuries and chronic arthritis and in other injuries. In these cases the prescribing of occupational therapy is based on the fact that the best type of remedial exercise is that which requires a series of specific voluntary movements which form an integral part of a more complex series of coordinated movements for the purpose of securing the end products and thus furnishes direct incentive for sustained effort.

In cases caused by injury it is believed that the occupational therapist would do well in following Kennedy's [8] suggestions that active exercise should be

7. Griffiths, H. E.: Rehabilitation After Fractures, in Rolleston and Moncrief: After-Care and Rehabilitation, London, the Practitioner, 1943.

8. Kennedy, R. H.: Active Exercise in Fracture Treatment, Arch. Phys. Therapy **22**: 720 (Dec.) 1941.

prescribed as soon as the fracture has been reduced, when the method of fixation has been decided on and when the fixation has been effected. A fracture patient enters the hospital as a healthy man with a fracture and not as a man physically or mentally sick. The less he is placed in the category with the sick patient, and the more he is treated as one who was well before the accident and who expects to remain well, the shorter will be his convalescence period. Because a leg is injured is no excuse for allowing the muscles of the neck, back and the three other extremities to deteriorate and to prolong greatly the convalescence.

The fracture patient needs work therapy—not a vacation but a hardening process. Ways and means should be devised to keep his mind and body occupied from the very beginning.

Occupational therapy needs to be introduced much more widely in general hospitals because, according to Kennedy, occupational therapy is many times more valuable than the usual types of physical therapy for these patients. As an occupant of a general hospital, the fracture patient is too often conditioned to becoming an invalid. Frequently he requires prolonged care to recover from his hospitalization rather than from his injury.

A fracture patient should be taught how to use all joints and muscles in the region of immobilization, commencing on the first day. He should be given general exercises immediately in order to preserve his musculature. While he is in bed he should be given a job that will occupy both his body and his mind and make him feel that he is still part of the moving world. As soon as the fracture patient leaves his bed he should be taught by some form of occupational therapy and, if possible, something similar to the type of work he performed before his accident.

Occupational Therapy[1] *with Reference to Fractures of Specific Regions.*—Fractures of the Upper Extremity: Wilson[8a] stated in part:

> All function of the upper extremity centers about and is subservient to that of the hand. The hand is the tool, and

8a. Wilson, P. D.: Treatment of Fractures in Specific Regions, in Mock, H. E.; Pemberton, R., and Coulter, J. S.: Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company, Inc., 1934, vol. 2, chap. 5, p. 47.

the forearm and upper arm, together with the various articulations, are merely the levers and gears that adapt the tool to its tasks and apply the power, and provide the means of movement. The usefulness of the upper extremity depends upon maintaining the delicate and multiple activities of the fingers

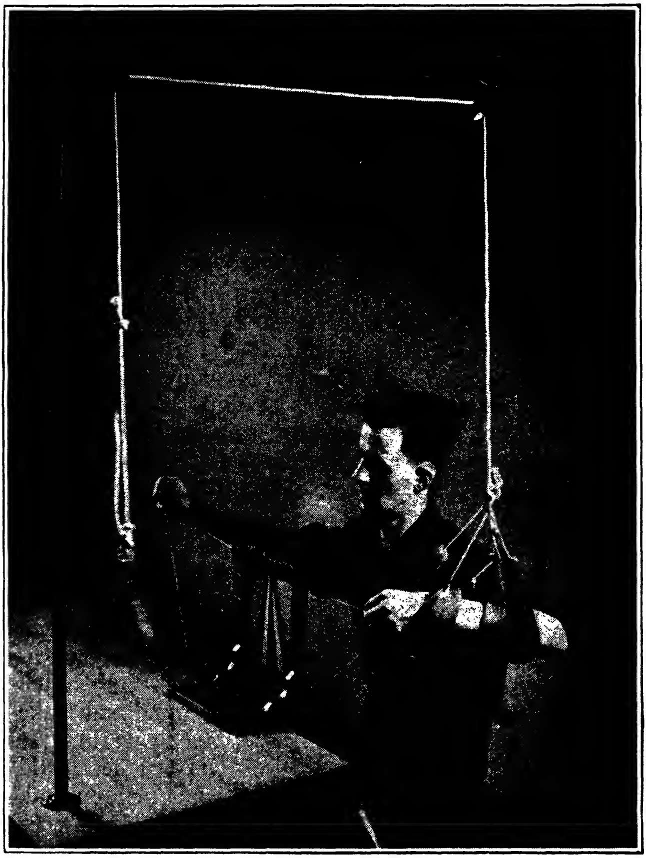

Fig. 5.—The use of a sling suspension to relieve gravity. Square knotting serves as the exercise with the arm supported.

and thumb. If these are lost, the result is almost as unfortunate as if the extremity were amputated.

The treatment of fractures of the upper extremity must therefore be directed with the constant consideration of the necessity of preserving the mobility of the articulations and the suppleness of the muscles.

Occupational therapy is particularly applicable in developing and maintaining functional usefulness of the hand.

Fractures of the Shoulder Region: A common disability in fractures of the shoulder region is weakness of the deltoid muscle. When occupational therapy is indicated, the arm should be removed from the splint

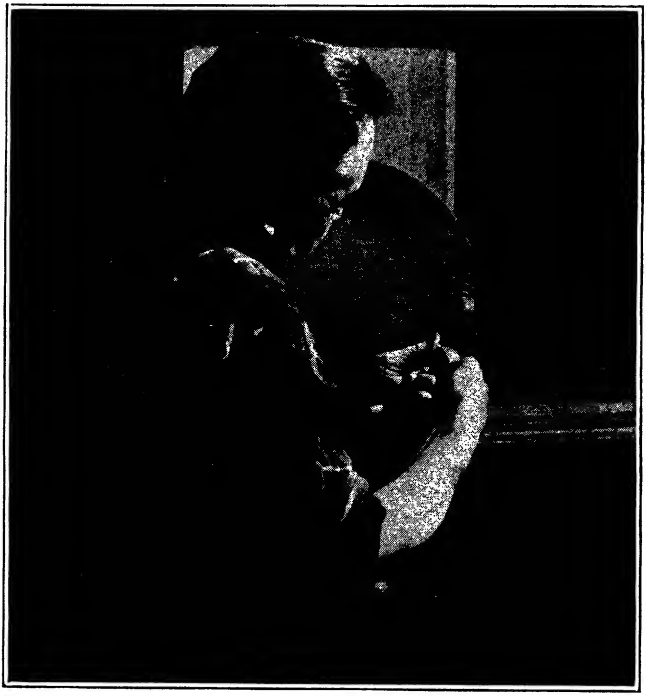

Fig. 6.—The use of regular screws and special ones with threads running in the opposite direction. In the position shown supination of the forearm is obtained. The same work with the arm held at a 45 degree angle from the body gives outward rotation of the shoulder.

with great care to prevent stretching of this muscle. Exercise may be given with the arm held at shoulder level in an overhead sling suspension apparatus (fig. 5).

When the strength of the deltoid muscle is equal to exercise without the sling suspension, a carefully graded program is started. At first, the weight of the arm will give enough resistance and only light activity is indi-

cated. Later, strength is increased through the resistance offered by the equipment and material used.

External rotation of the shoulder is essential for normal range of shoulder motion. This may be obtained through the use of the screw driver and special screws with threads running in a direction opposite to normal. The position of mechanical advantage for the outward

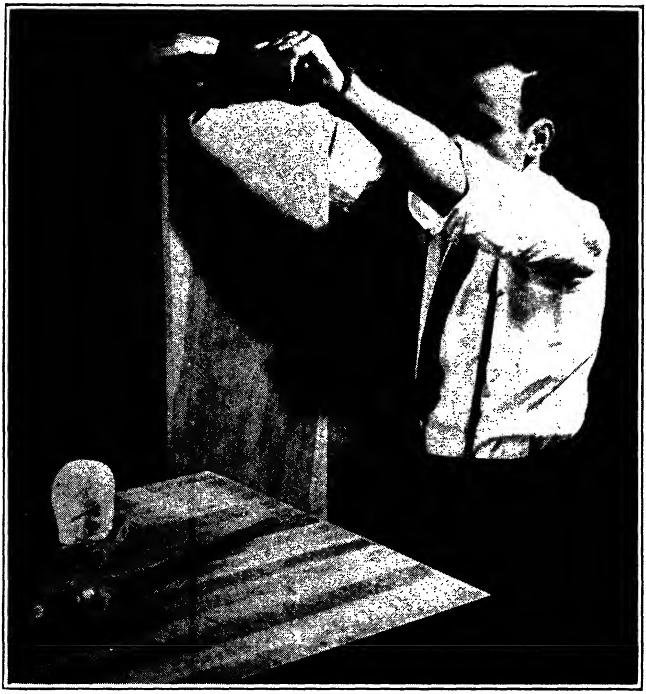

Fig. 7.—Carpentry, with the work at or above the shoulder level, is used for exercise for the back and shoulder. Tools requiring bilateral action prevent compensation.

rotators is with the arm held at a forty-five degree angle to the body (fig. 6).

Carpentry with the use of various tools is adaptable for exercise of the shoulder (fig. 7), as well as for exercise of the hand, forearm and elbow.

Fractures of the Elbow: Fractures in or near the elbow joint frequently result in limitation often of

motion of the elbow, supination of the forearm and loss of function in the wrist and hand.

The miter saw may be used as exercise for elbow extensors (fig. 8).

Care must be taken to prevent the patient from compensating and getting motion in the shoulder instead of the elbow. When treating the forearm pronators

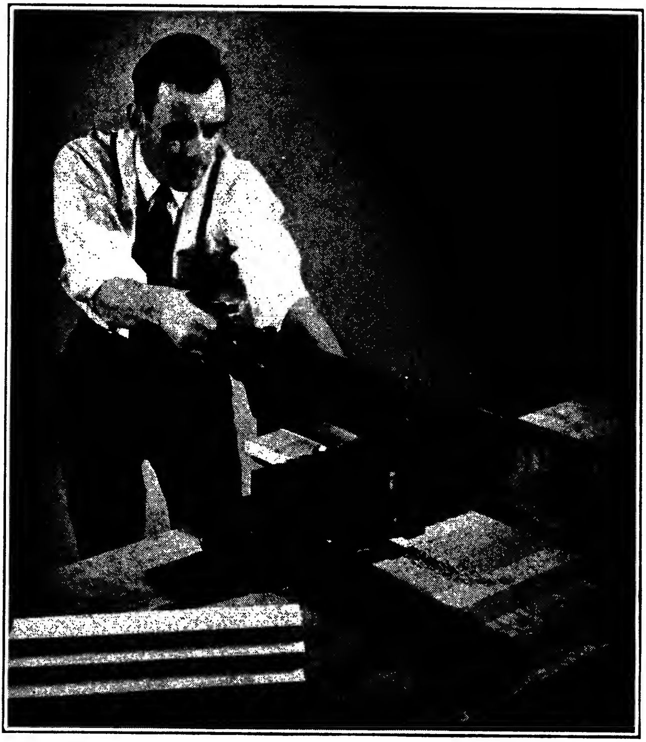

Fig. 8.—Sawing increases the muscular power of the flexors of the upper arm and the extensors of the elbow.

and supinators, it is advisable to have the upper arm held to the side of the body in order to prevent rotation in the upper arm instead of localizing the action in the forearm. The aforementioned special screws (fig. 6) are used for this exercise.

There are many useful occupations for increasing strength and motion in the elbow and the forearm.

For the extensors planing, sawing, filing, sandpapering, knotting and loom weaving of various kinds are some of the possibilities. Many of these occupations may also be adapted for treatment of flexors.

Knotting (fig. 5) is also exceedingly good for supination of the forearm and may be adapted for pronation. It is a bilateral exercise preventing a muscular compensation.

Fractures of the Wrist (Colles' Fracture): Soon after the cast is applied, motion in all unaffected joints may begin. With the wrist completely immobilized in a cast, activity requiring full flexion and extension of the fingers should be given. Stiffness in the elbow and the shoulder should also be prevented through activity in full range of motion. The patient is usually fearful of exercise, and therefore interesting activities which distract his attention are preferable to monotonous subjective exercise.

After removal of the cast exercise should be planned to increase extension of the wrist and flexion of the fingers. One method of accomplishing this is to use tools with large handles in sanding wood, filing, etc., as shown in figure 9.

Fractures of the Lower Extremity: Wilson [7] stated in part:

> The functions of the lower extremity are of a highly specialized type and have to do chiefly with weight bearing and locomotion.
>
> The ordinary individual can therefore tolerate a certain degree of limitation of the movements of the hip, knee or ankle with little functional loss; in dealing with fractures of the lower extremity, preservation of skeletal alignment is more important than restoration of complete mobility. This does not mean to imply that one should not aim for full restoration of movement, but that early mobilization of the articulations should never be prescribed if it involves the slightest risk of disturbing the alignment.
>
> Also, greater emphasis is to be placed upon active exercises performed regularly by the patient than upon massage or passive mobilization.

The first exercise for fractures of the lower extremity should be non-weight-bearing. An apparatus providing such exercise for hip, knee and ankle and maintaining alinement is the bicycle jigsaw. Special pedal attachments make it possible to convert this exercise from one using the extensors only to a pulling action using

the flexors. Pedal and seat shafts of extra length increase the flexibility of this apparatus and allow full flexion of the knee (fig. 10).

In the curative workshop power reduction factors, such as psychologic inhibitions, pain, fear and fatigue, are eliminated as much as possible.

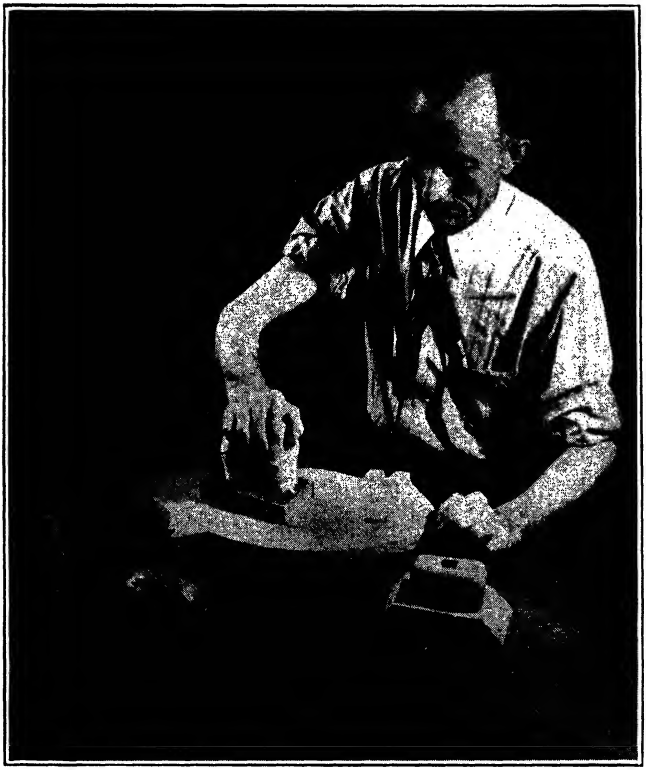

Fig. 9.—The handles of tools and sandpaper blocks are built up to fit the hand and are reduced in size as the flexion of the fingers increases.

It is believed that the psychologic inhibitions of the workshop require that the environmental conditions there be superior to those of the man's normal environment. If one can surround the patient in the workshop with a feeling of well being beyond that to which he is accustomed, one will have accomplished a great deal. This sense of well being can be accomplished by interior

decoration, orderliness and absolute cleanliness. To motivate a convalescent patient to leave the ease and lazy life of his personal environment requires that he make considerable mental effort, and this effort can be stimulated through the patient's desire to be in a workshop.

Pain can be lessened by cooperation between the hospital staff and the physical therapy department. The physical advantages of the curative workshop situated close to the physical therapy department are obvious. By heat, diathermy, whirlpool bath, massage and muscle stimulation, pain is diminished and exercise is facilitated.

The patient's fear should be eliminated by cooperation between the occupational therapist and the patient's employer. The physician in charge of a department of physical medicine and the occupational therapist should not give testimony about the patient's condition for the insurance company or for the employers before a court or a workman's compensation board. If this is done, the news is spread that the occupational therapy department is trying to get the patient back to work, not for his benefit, but for the insurance company. This causes fear in all the patients and a consequent loss of confidence in the workshop.

The patient's fatigue can be guarded against by cautioning him that no form of work or play should be continued for more than a relatively short time. Fatigue can be measured in the arm by a hand grasp strength test and in the leg by a pull test for the quadriceps muscle. Fatigue may be mental as well as physical, and for this reason a curative workshop should have both recreational therapy and exercise classes.

Recreational therapy, through competitive games, can often supply the desired exercises that the patient requires. The devices used may be a checkerboard on the floor or wall, darts, pingpong, horseshoes and pool tables.

Recreation gives mental relaxation after the workshop. Games are played with the technician and are manipulated in such a way that the patient is encouraged to strive against and to excel the technician. During rehabilitation of an injured man, one may spend a long period of time training him vocationally, but if he is unable to achieve his proper position under social condi-

tions he will never become really rehabilitated. A man must be helped to adjust himself to a group and to be at ease in conversation with his companions so that he can join in the games of the group and become a part of it. Citing one example: A man came to the

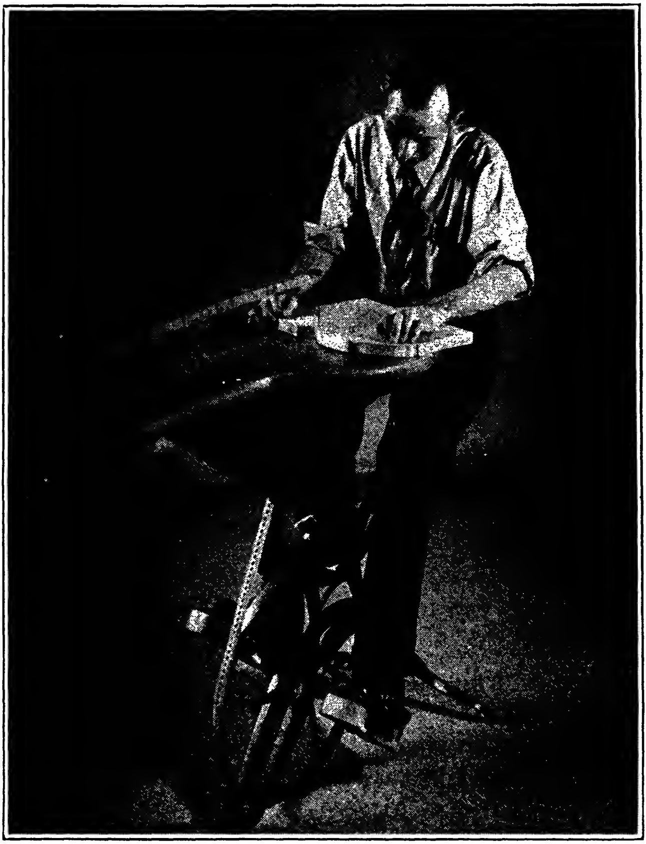

Fig. 10.—The bicycle jigsaw is used to increase the strength of the flexors or extensors of the hip and knee. With special pedals and adjustable long and short shafts for the pedals and the seat the patient may pull the pedals around to increase flexion or push them for extension.

department with an artificial hand. Although we were successful in encouraging him to use both his hand and his arm to saw wood, to hammer nails and to do a pretty good job in the wood working shop, he did not

feel at ease socially and kept his artificial hand in his pocket when not in actual use. It was not until he found he excelled at the pool table that he realized that although he had an artificial hand he was on a par with others. Thus, social accomplishment played an important role in his future life.

Classes in remedial exercises not only give therapeutic exercises but may eliminate mental fatigue. Dr. Storms in his Workmen's Compensation Clinic in Toronto, Canada, makes excellent use of these classes. He conducts classes for leg exercises from 9 to 9:30 a. m. and 1:30 to 2 p. m., foot classes from 9:30 to 10 a. m. and 2 to 2:30 p. m., hand classes from 10:45 to 11 a. m. and 3 to 3:15 p. m., and arm exercise classes from 11:30 to 12 m. and 4 to 4:30 p. m. In the leg classes the patients (1) walk over a floorlike apparatus built to simulate uneven ground, (2) walk over a MacKenzie inversion tread, (3) walk over steps of various heights, (4) along a bench 18 inches high and 10 feet long to preserve balance and induce good posture, (5) climb up and down a platform with ladders on both sides 5 feet high, five ladder rungs to climb to the top where there is a platform 3 feet long protected on the sides by 30 inch high hand rails, with another ladder on the end, so that it necessitates climbing up five rungs and down five rungs (fig. 11), and (6) work on a treadmill with hand rails. These classes are organized into groups, and every man with a leg disability attends the leg exercise classes as soon as he is able to do so. The hand and arm groups complete hand and arm exercises with the patients sitting in chairs.

In the treatment of the injured workman, Griffiths'[9] observations on the conditioned reflex of industry should always be observed. He says in part:

> The conditioned reflex adds the power producing factor of repetition, and this in the deliberately acquired reflex was originally the result of conscious effort. Impulsive action, although not a truly acquired conditioned reflex, is produced by the cortical memory of deliberate action freed by practice from psychological inhibitions associated with conscious deliberation. Deliberate action becomes an effort of will power or thought; but for deliberate muscle action to be developed into a state of skilled muscle action a period of training is necessary, requiring concentrated mental effort and practice, and this can only lead to the desired skilled action as experience is

9. Griffiths, H. E.: Treatment of the Injured Workman, Lancet 1: 729 (June 12) 1943.

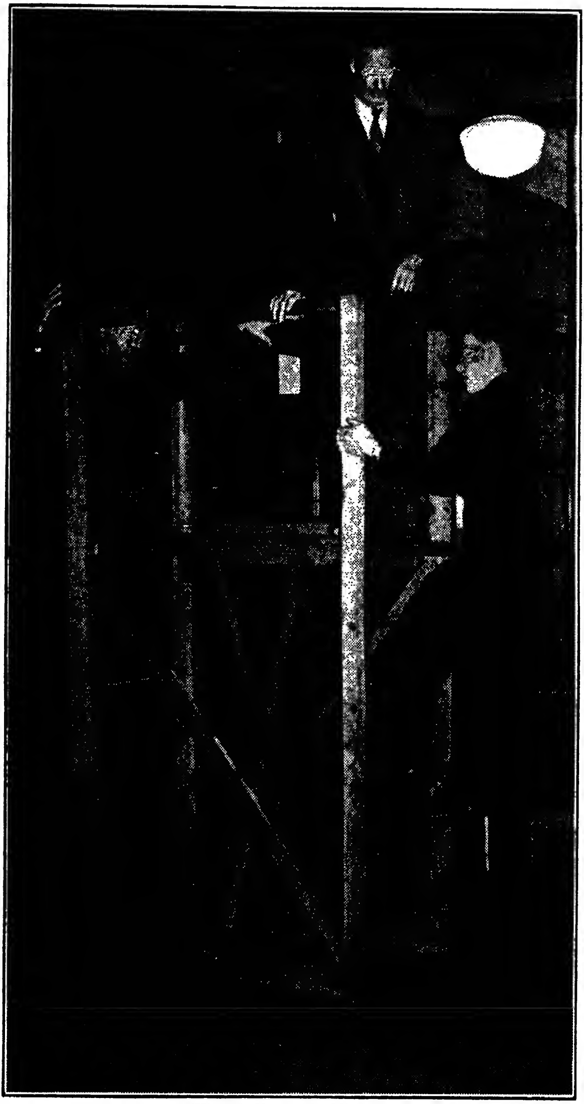

Fig. 11.—Apparatus for leg exercises at Workmen's Compensation Clinic, Toronto.

obtained. Finally, something more is needed before the skill becomes expert. This extra something is not only experience but represents a definite advance in pure psychical effort.

The inhibition of the conditioned reflex may be either external or internal. The external inhibition is produced by some excitatory processes other than the conditioned stimuli in the central nervous system, and of these pain, the anticipation of pain or other fear are of greatest importance.

The conditioned reflex of industry is a very complex affair. Take, for example, the skilled carpenter using a saw. The action is one of pushing and pulling the saw, but long practice has produced a conditioned reflex in which each stroke of the saw corresponds almost exactly with the previous or succeeding strokes. The reflex developed is a nice example of negative successive induction, but it is not the simple affair of alternate contraction and relaxation of the biceps and triceps or of the serratus magnus and latissimus dorsi muscles. The beautifully balanced muscle action involved depends on many different conditioned stimuli.

To mention only a few of these: There are the touch stimuli from both hands. In the saw hand a definite tactile discrimination is associated with the man's own saw (as every tradesman uses his own tools). Thus the same part of the skin of his hand is stimulated every time he grips this particular saw. There is the stimulus of bone vibration set up by the wave-length of the saw being used, so that the farther the saw is thrust the shorter the vibration wave, ultimately suggesting the point at which the reflex action of the thrust shall be reversed. There is in addition the sound reflex, the rasp of the saw, and here again the note alters with the progress of the saw through the wood. When the conditioned reflex is first established a knot in the wood will cause a temporary interruption in the reflex path and tend to throw the muscles out of proper coordination so that there must be a period of conscious action before reflex action is reestablished. But as time goes on the extra resistance of a knot in the wood itself produces a superimposed conditioning stimulus and sets forth a bigger muscular effort without interfering with coordination.

In considering all these industrial conditioned reflexes the law of summation of conditioned reflexes must be borne in mind. This states that when different conditioned stimuli will each call forth a similar reflex, the stimuli acting together will produce a greater effect than they do when acting alone. A conditioned reflex may be reduced but not lost by interference with one of the conditioned stimuli, provided the other conditioned stimuli are sufficiently strong to overcome the inhibiting effect of the lost stimuli.

With the injured workman, bed treatment is only a minor problem. Over 99 per cent of the injured can and should receive ambulatory treatment, and this must be designed to

ensure that they use their conditioned reflexes and so secure the maximum amount of exercise with the minimum amount of fatigue. Man's ordinary walking gait is a combination of postural reflexes with the stepping reflex and various conditioned reflexes, not the least of which is produced by the sensation of the impact of the ground transmitted through the sole of a shoe or boot. Treatment therefore must be aimed at restoring normal walking conditions at the earliest possible moment.

Finally we come to the question of vocational exercise associated with the patient's work. This aspect of treatment must be attempted only when its practice will not produce any of those factors which inhibit the conditioned reflexes which are the foundation of his skill.

As an example take the carpenter who has an injured wrist and is asked to use a screwdriver. The normal action of driving a screw is for him a conditioned reflex, but pain inhibits this reflex action and it does so in this way: In the first turn made, perhaps the normal conditioned reflex was obtained, but with it pain; the movement now becomes conscious movement and the anticipation of the pain produces a static contraction of muscle to resist the anticipated movement. This inhibits the conditioned reflex with resultant incoordination of muscle action and loss of power. But the effect does not end there. With pain and work linked in the man's mind, fear is born—the fear of incapacity for work—and this fear still further inhibits the conditioned reflex. It has been a mistake, therefore, to attempt to restore the conditioned reflex of the man until the arm has become relatively free from those factors of pain and stiffness which would inevitably inhibit the desired action.

What has been said of vocational therapy applies equally to so-called "light work." The man has been given work of a lighter character in his own trade before he is sufficiently free from pain and while still liable to early fatigue. As a result, he develops inhibition of his previously work-conditioned reflexes, leading to increased clumsiness and to despondency. If he has not been employed at the lighter forms of his old job, all too often he has been given work which involves industrial degrading—a bricklayer becomes a tea-boy—and one of his worst fears is realized. His mind now becomes so concentrated on the injured part that subconscious movement becomes almost impossible and the most rapid road to recovery—restoration through exercise—is barred to him.

We are enlarging the floor space of St. Luke's Hospital Curative Workshop to give our patients the necessary work to take advantage of the industrial conditioned reflexes. Dr. Storms in the Workmen's Compensation Clinic at Toronto, Canada, gives his

patients occupational therapy that eventually works into industrial conditioned reflexes.

Following are some examples of Dr. Storms's occupational therapy workshop: A bricklayer with a disabled hand was given a thousand bricks and told to arrange a part of them in a design on the floor first. Later the bricklayer was handling all the bricks without mortar, to build walls. He knew how many bricks he needed to handle at his job each day, and from the number he was able to handle each succeeding day in the workshop he saw how he was improving and how close was the time of his return to work. A sign painter was ready for work, except that his grip and shoulder muscle were not strong enough for him to pull on the ropes that raised and lowered his swinging scaffold; Dr. Storms rigged overhead a compound pulley and had the patient pull on a rope and lift weighted bags of sand attached to the other end of the rope, just as was done at his occupation. When he was able to lift a certain weight, the painter was confident that he was ready to return to work (fig. 12).

A brake is also arranged for switchmen in this workshop, and there is a platform built waist high for freight workers. Ordinarily boxes are filled with weighted loads. The disabled patient loads the boxes onto a wheelbarrow and wheels them to another place, where he then unloads. A large tree trunk to saw with cross cut saws is provided for lumberjacks. Wood is split by blacksmiths or other workmen who employ mallets or hammers. A gravel box is provided with a fence that can be varied in height. Laborers who use shovels at their work can shovel gravel over this fence (fig. 13). Dr. Storms has rigged hand and foot levers which are weight regulated by cans or bags of sand attached to the beams for steam shovel operators (fig. 14). Painters are given work with paints and brushes in this workshop.

This principle of occupational therapy sometimes results in rather humorous situations. A tombstone engraver was injured in the arm. In the workshop he was provided with a cutting stone and other tools of his trade. During the course of his treatment he engraved "In loving memory of" and the names of the physical and occupational therapy technicians on a tombstone.

Occupational therapists are required to visit the industries, railroads or other places where the patients had been employed prior to their admittance to the hospital in order to observe men at work in these indus-

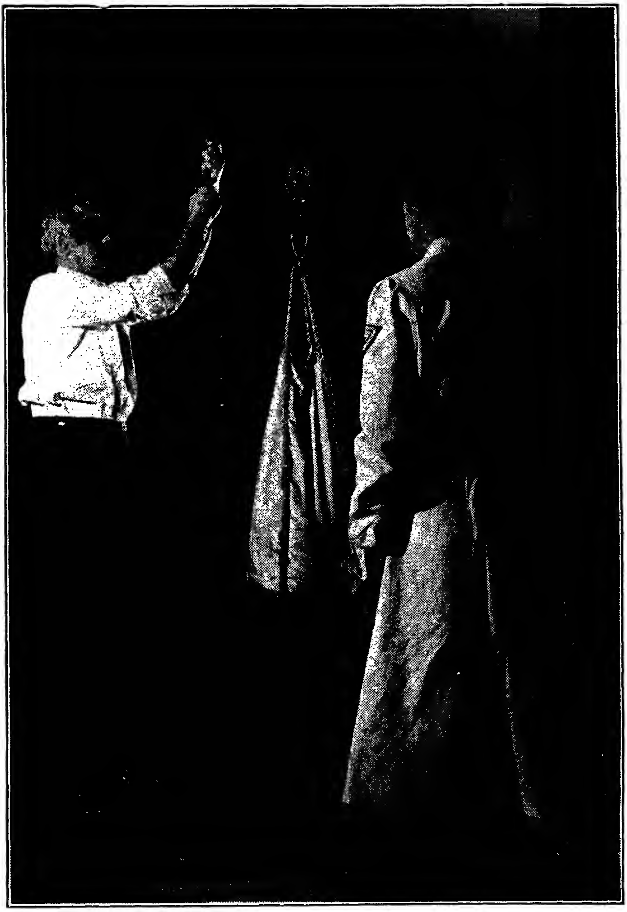

Fig. 12.—Apparatus for arm and shoulder muscles. A sign painter exercising his grip and shoulder muscles at Rehabilitation Center, Boston.

tries and therefore to be better equipped to devise occupational therapeutic apparatus and to prescribe methods to fit the diasability of the patient with due consideration of his future employment. Therapists

should know how hard the men must work in a given trade and what the trade names are for each occupation. If a patient states that he is a "holder-up," the occupational therapist should know that he "holds a dolly for the rivet" and should also know what a

Fig. 13.—Gravel box and adjustable fence apparatus for reconditioning an industrial conditioned reflex at Rehabilitation Clinic, Boston.

"dolly" is and weighs, what muscles are affected in this operation, what the joint movements are and what the patient requires in the methods of occupational therapy in order to get him back to his work.

Occupational therapy is one of the best forms of treatment for injuries. It diverts the patient's mind

from his injury and improves his morale. Mock[10] stated in a previous edition of the Handbook of Physical Therapy:

One of the commonest causes for traumatic neuroses is failure of continuous active treatment until the surgeon is assured that his patient is well on the way to an economic end result; that is, able to carry on once more. The diagnosis of a broken back, a skull fracture or a fractured pelvis often strikes fear and dread into the heart of the patient; yet the treatment of these conditions in a large majority of cases is comparatively simple and the end results are extremely good. Many times treatment consists in simply putting the patient

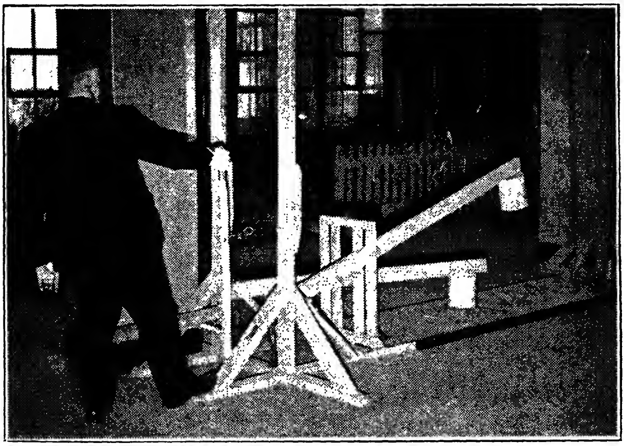

Fig. 14.—Apparatus for reconditioning industrial conditioned reflexes at Workmen's Compensation Clinic, Toronto. A steam shovel operator pulling hand lever where resistant force is regulated by positions of weight attached to beam.

to bed and keeping him as quiet as possible from six weeks to three months or, in some cases, in addition to rest, of traction applied to the lower extremities. The surgeon makes his daily round satisfied with the treatment of the physical condition and the progress being made and never recognizes or even dreams of the fear and anxiety that are gnawing at the patient's mind. When the day comes for the patient to leave his bed and begin to move about, the surgeon is disgusted with the lack of cooperation on the part of the patient, the unwillingness to try to help himself and the absurdity of his complaints.

10. Mock, H. E., and Abbey, M. L.. Occupational Therapy, in Handbook of Physical Therapy, ed. 3, Chicago, American Medical Association, 1939.

All such patients, in addition to the actual surgical treatment, need properly directed physical therapy and occupational therapy, which are the logical adjuncts to the usual surgical procedures. . . . Occupational therapy keeps a patient's mind and hands employed for a large part of the day, filling in the gaps between the surgeon's visits and the physical therapy and leaving little time for the fears and germs of traumatic neuroses to develop.

CARDIAC CONDITIONS

One of the big workmen's compensation insurance companies recently stated that the patient with heart disease but with good compensation may do well in special placements which do not require physical effort sufficient to aggravate the crippled part. In the average stable industry there are about 8 per cent of the entire personnel who are cardiac patients. This group of trained artisans need not and should not be discarded. With proper medical supervision, with shifting of placement and general oversight, they can continue in active service for many years without shortening or jeopardizing their lives. This group does not include the many persons who die suddenly of a heart attack and who had previously shown no symptoms referable to the heart. Dr. W. D. Stroud, a member of the Council on Industrial Health of the American Medical Association, published a detailed discussion of this subject.[11]

FUNCTIONAL CLASSIFICATION OF PATIENTS WITH HEART DISEASE

CLASS I.—*Patients with Heart Disease and No Limitation to Physical Activity.*—Ordinary physical activity does not cause discomfort. Patients in this class do not have symptoms of cardiac insufficiency, nor do they experience anginal pain.

CLASS II.—*Patients with Heart Disease and Slight Limitation to Physical Activity.*—Patients in this class are comfortable at rest. If ordinary physical activity is undertaken, discomfort results in the form of undue fatigue, palpitation, dyspnea or anginal pain. Competition in athletics and other strenuous activity, even hurrying, are to be avoided. Activity should be graded according to cardiac tolerance. A vocational plan

11. Stroud, W. D.: The Rehabilitation and Placement in Industry of Those Handicapped with Cardiovascular Disease, J. A. M. A. **105**: 1401 (Nov. 2) 1935.

should be made according to the permanent mechanical involvement of the heart.

CLASS III.—*Patients with Heart Disease and Pronounced Limitation of Physical Activity.*—Patients in this class are comfortable at rest. Discomfort in the form of undue fatigue, palpitation, dyspnea or anginal pain is caused by more than ordinary activity. Occupational therapy is first used to induce rest from the cardiovascular standpoint, allowing the circulation to slow down and the reserve power to overcome infections. By this means ultimate damage is minimized. Light activities and a program of graded exercise may later be indicated.

CLASS IV.—*Patients with Heart Disease and Inability to Carry on Any Physical Activity Without Discomfort.*—Symptoms of cardiac insufficiency or of the anginal syndrome are present in patients in this class, even at rest. If any physical activity is undertaken, discomfort is increased. In this class, as in class III, occupational therapy is used to induce rest as well as to decrease anxiety and fear. The program is limited to mental activity and may prove of distinct value as a palliative measure.[12]

In a large general hospital, such as St. Luke's Hospital, the occupational therapy department is frequently ordered to give preventive or diversional occupational therapy to persons with heart disease. It is believed that these patients should be given functional occupational therapy in the curative workshop to improve their general condition, to aid in their mental rehabilitation and to aid their attending physician to prescribe the amount of exercise that his cardiac patient can take. Too often such a patient is sent home from the hospital with such inadequate instructions concerning exercises as "Do not overdo." Although exercise cannot be definitely prescribed, it should not be left entirely to the discretion of the patient. Mackenzie[13] maintains that the object of exercises—the strengthening of the heart muscle—is too often forgotten. He states that, by summarily laying down that so many yards should be walked one day and so many another

12. Manual of Physical Therapy, War Medicine **2**: 295-329 (March) 1942.

13. Mackenzie, M., and Orr, J.: Principles of Diagnosis and Treatment, in Heart Affections, ed. 2, London, Hodder & Stoughton, 1923.

day, the physician shows that he has failed to take into account the peculiar nature of the heart functions. The power of response of the heart to effort varies greatly in the same individual from time to time—one day a patient with an impaired heart can undertake a great deal of effort with comparative comfort, whereas on other days the same amount of effort causes him distress. This is because the heart may be disturbed by a variety of conditions such as gastric or intestinal disturbances, lack of sleep and the state of the weather. The patient's sensations are therefore a valuable guide and may indicate the amount of effort which can be undertaken by him with safety in all circumstances.

Stroud and Comstock[14] state that patients with organic heart disease who are unable to carry on any physical activity need occupational therapy which gives practically absolute rest from a cardiovascular standpoint. Here, remuneration for articles sold, future vocation and so on should be minor considerations. If practical they should certainly be taken into account, but not at the expense of the main object of such therapy; that is, mental and physical rest in order to relieve the circulation of much of the load which the heart must carry. It is the relief from this burden which allows the heart muscle, previously unable to carry on its work of keeping up an efficient circulation, to regain much of its reserve, so that if it is not again asked to carry too heavy a load it may do its work efficiently for many years. Proper occupational therapy, by lightening the burden placed on the circulation by mental and physical activity, may, in children with active infections damaging their heart muscle and heart valves, allow circulation to slow down and thus help these children to call on their reserve to overcome the active infection and minimize the ultimate damage to their hearts. These are the two large groups which come under the class of patients with organic heart disease who are unable to carry on any physical activity, those with active infections damaging the heart and those with already damaged hearts which have been required to carry too heavy a circulatory burden through physical and mental effort and whose hearts have temporarily failed. These authors further state that,

14. Stroud, W. D., and Comstock, C. R.: Physical Therapy in Cardiovascular Disease, Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company.

when such patients progress so that they are able to carry on diminished physical activity or their habitual physical activity, vocational training with the ultimate object of a definite vocation, and finally placement through a bureau for the handicapped, are as important as is the occupational therapy itself.

HYDROTHERAPY

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Since water is so abundant and readily obtainable, its benefits as a therapeutic agent are often forgotten. Elaborate apparatus is not necessarily required in the practice of hydrotherapy.

The physiologic effects of water, as employed in hydrotherapy, are essentially the same as the effects of heat and cold considered in the chapter on heat by Pemberton. Only hydrotherapeutic methods requiring inexpensive apparatus are considered in this article. In some instances, the methods suggested may be explained to patients who can carry them out at home.

LOCAL APPLICATIONS

HEAD COMPRESS.—Cold compresses for the head are useful to lessen febrile headache and usually should accompany other hydrotherapeutic procedures for fever.

Apparatus.—Turkish towel and basin of ice water.

Method of Application.—The towel is immersed in ice water, wrung out, and applied to the head like a turban. An ice bag may be applied over it.

THROAT COMPRESS.—Throat compresses are useful in tonsillitis and laryngitis.

Apparatus.—Two strips of linen three inches wide and long enough to reach under the chin from one ear to the other. One piece of flannel three and one-half inches wide and long enough to reach around the head, overlapping several inches at the top, and with slits cut to permit the passage of the ears.

Method of Application.—The strips of linen are immersed in water at 60 F. and wrung out. Then they are placed upon the flannel and applied to the neck so that they reach under the chin from one ear to the other. The flannel strip goes over the ears and is

drawn tightly together on top of the head and secured by safety pins. The compress is changed when it becomes warm and dry.

Chest Compress.—Chest compresses are useful in bronchitis and pneumonia.

Apparatus.—A piece of linen cut in such size and shape (see fig. 1) as to fit the entire upper back and chest from the clavicles to the umbilicus, with arm and neck spaces to allow the upper edges of the compress to reach over the shoulder and to be pinned together. A piece of flannel of the same shape, but an inch wider and longer, is also necessary.

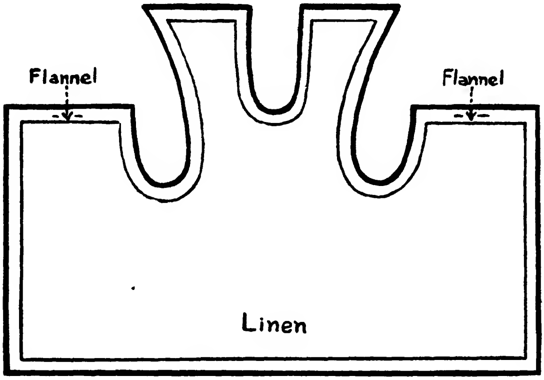

Fig. 1.—Chest compress, linen on flannel.

Method of Application.—The piece of linen is wrung out of water at 60 F. and spread upon the piece of flannel so that there is an edge of flannel about one inch wide all around. Both are folded together with linen on the inside; the patient is turned on his right side, and the compress is placed upon the bed with the folded edge along the right side of the patient. The compress is opened and the unfolded arm space is placed under the left axilla. Now the patient is carefully turned upon his back, his arms raised and the other portion of the compress is brought around the right axilla and forward over the front of the chest. The flannel is brought over to cover the linen and secured by safety pins in front. The arms are lowered, the linen flaps are brought above the shoulders, and the

flannel flaps are then secured over them by one pin upon each shoulder. A second compress should be prepared as above and renewed every hour.

TRUNK COMPRESS OR HALF PACK.—According to Fantus,[1] the trunk compress is the most useful form of antipyretic pack, because it is mild enough to be used for children and collapsed patients and it can be used for very high temperatures in intervals between more radical procedures.

Apparatus.—For an adult a folded sheet, and for a child a Turkish towel, sufficiently wide to cover the entire trunk from the axilla to the pubis, and long enough to reach around the entire body. A flannel binder, a little wider and longer.

Method of Application.—The towel or sheet is wrung out of water at 60 to 70 F., snugly wrapped around the body, covered with the dry flannel, and this is secured by pins. It is changed every two hours for a temperature above 104 F. and every hour for fever above 105 F.

HOT FOMENTATION COMPRESS.—*Indications.*—Lumbago, bursitis and sciatica.

Apparatus.—Two pieces of blanket about eighteen inches square. A wringer constructed from a large towel, with sticks, 24 inches long, sewed to the narrow borders so that the ends project.

Method of Application.—The wringer is placed in a basin and the blanket pieces are laid upon it. Boiling water is poured over these until they are saturated. The blanket pieces are now wrung out, until all hot water is expelled, by twisting the sticks of the towel wringer in opposite directions. It is most important that not a drop of free water remains in the blanket compress, or burns will be produced.

A folded dry blanket is placed under the affected part, and the skin is covered with vaseline. The blanket compresses are slipped out of the wringer and placed upon the area to be treated. The dry blanket is then brought around the part and over the compresses, which are renewed every fifteen minutes.

HOT MOIST DRESSINGS. — *Indications.* — Spreading infection.

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1. Fantus, Bernard: Fever Regimen, J. A. M. A. **103**: 7; 484-491 (Aug. 18) 1934.

Apparatus. — Large sterile dressings, and warm sterile solutions such as boric acid or salt solution. A small, electric room heater, or electric lamp baker.

Method of Application.—The sterile dressing is put about the affected part and moistened, not saturated, with the warm sterile solution. A thick sterile dry pad is applied around this. Over this is suspended the electric room heater or an electric lamp baker so as to keep the dressings warm. Every two hours the outside covering of the dressing is opened to moisten it with the sterile solution. Once every twenty-four hours the dressings are entirely removed and replaced, with careful aseptic technic, by fresh sterile dressings.[2]

HOT SITZ BATH.—*Indications.*—Prostatitis, painful hemorrhoids, and dysmenorrhea.

Apparatus.—An ordinary washtub may be used for home treatment.

Method of Application.—The water in the tub should reach to the level of the patient's umbilicus when the patient is sitting in the tub with the legs outside. The water should be at a temperature of 98 to 104 F. Duration from fifteen to thirty minutes. The patient's chest and shoulders are covered with a blanket and the feet and legs wrapped snugly in a separate blanket.

THE WHIRLPOOL BATH. — *Indications.* — Painful stumps; painful and adherent scars; purulent wounds; indolent ulcers; acute arthritis; healed fractures of the extremities; inflammations of joints, muscles and tendons of the extremities. The whirlpool bath may be given advantageously as a preparation for massage and movement which by the use of this bath are rendered easier and less painful.

Apparatus.—The best equipment for this bath is a specially manufactured vessel of suitable size to accommodate the arm or leg, with water delivered at high temperature and mixed with air by hydrostatic pressure or by an electric mixer. The temperature of the water is controlled by a thermostatic valve; it is started at 100 F. and increased to the patient's tolerance (approximately 115 F.).

Duration of the bath is from fifteen to thirty minutes.

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2. Kanavel, A. B., and Koch, S. L.: Treatment of Infected Wounds on a Surgical Service, Bull. Am. Col. Sur. Sept. 1930; pp. 19-27.

If such an apparatus is not available, the Council on Physical Medicine of the American Medical Association has prepared directions by which a local plumber may make such a bath from a wash boiler and ordinary pipe fittings.

GENERAL APPLICATIONS

All general hydrotherapy applications should be given in a warm room.

ABLUTION is the simplest antipyretic procedure.

Apparatus.—A rubber sheet or piece of oil cloth, blankets, ordinary sheets, and a wash cloth.

Method of Application.—The nude patient is on a sheet spread over the rubber sheet or piece of oil cloth, supported on the sides by rolled-up blankets or sheets and drawn at its lower edge into a trough leading into a bucket at the foot of the bed. The first ablution is given at 80 F. and the temperature of the water is reduced one degree daily, or every other day, to 60 F.

The chest, arms to the elbow, back, abdomen and lower extremities to the knees are successively bathed by freely applying the water with a wash cloth. The water is dashed quickly on the skin and is followed by gentle friction with wet hand or coarse bath mitten. This procedure is not sponging.

The application is made to the entire surface of the body two or three times, but the procedure should be stopped sooner if the skin does not warm up after the friction. The patient is dried (or not dried if a prolonged effect is desired) and wrapped in a dry sheet.

SHEET BATH is used as an antipyretic measure, intermediate in effect between ablution and the tub bath.[1]

Apparatus. — Rubber sheet or oil cloth, blankets, sheets, water pail and a cup.

Method of Application.—The bed is prepared as for ablution. A sheet is folded, dipped in water from 80 to 60 F., and applied to the patient as described and illustrated under the Full Wet Pack. This cold sheet is rubbed and patted by the nurse until it is warm. As soon as one part of the body is thoroughly warmed, water, 70 to 60 F., is dashed on from the pail by means of a cup or is squeezed from a sponge. The sheet is again rubbed until warmed. The entire surface of the body, except the legs below the knees and arms below

the elbows, is gone over until the sheet does not warm up as quickly as before or until the patient shivers.

The antipyretic effect may be enhanced by allowing the patient to remain in the wet sheet, withdrawing the rubber sheet or oil cloth, and wrapping him in a blanket, permitting him to remain for a half-hour, or longer if he is sleeping.

Drip Sheet Bath is useful in chronic arthritis in place of a cabinet bath and Scotch douche.

Apparatus.—Sheet, a wash tub and a pitcher.

Method of Application.—In a warm room the patient stands in a tub containing a foot of water at 106 F. A sheet is folded as described under Full Wet Pack and saturated with water at 80 F. The patient is directed to raise his arms. The sheet, not wrung out, is unfolded so that the lower border remains in the tub. The left border of the sheet is placed under the patient's right axilla, and he is directed to lower his right arm to hold it in place. The sheet is drawn across the chest and beneath the left axilla and secured by lowering the left arm. The sheet is then passed over the right and left shoulders and tucked in at the neck and between the legs. The nurse then rubs and slaps successive parts until they feel warm. Water at 70 F. is poured from a pitcher, and the parts are again rubbed; duration is from two to five minutes. The patient is now unwrapped, taken out of the tub, and quickly dried.

Full Wet Pack.—*Indications.*—Insomnia, nephritis, arthritis, psychosis and psychoneurosis.

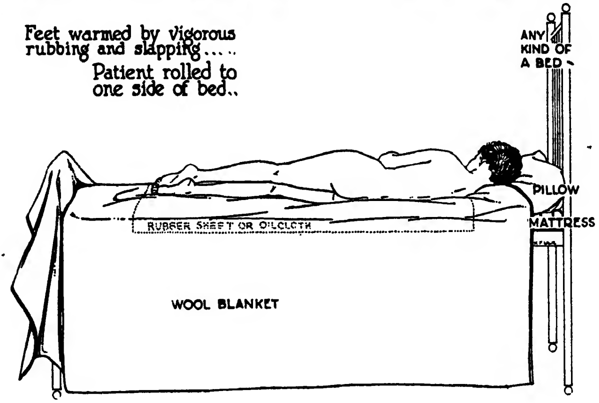
Contraindicated in circulatory disturbances, cardiac derangement, in extreme exhaustion and when reaction would be problematical.

Apparatus. — Any ordinary bed and mattress. If packs are to be repeatedly renewed, two beds and double equipment must be provided. Dishpan or large basin of cold water on small table or chair. Pillow. Rubber sheet or large pieces of oil cloth. One sheet, size 81 x 90 inches. One or two woolen blankets, size 81 x 90 inches. Small towel. Hot water bottle or soapstone.

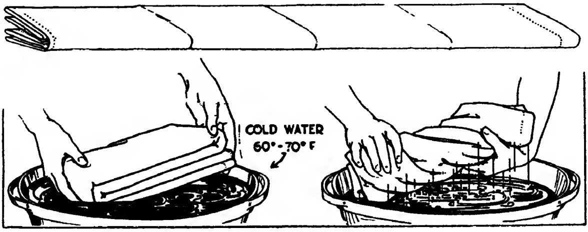
Preparation.—One person may envelop a patient in a wet sheet pack. If the patient is violent, two assistants may be required.

FULL WET PACK

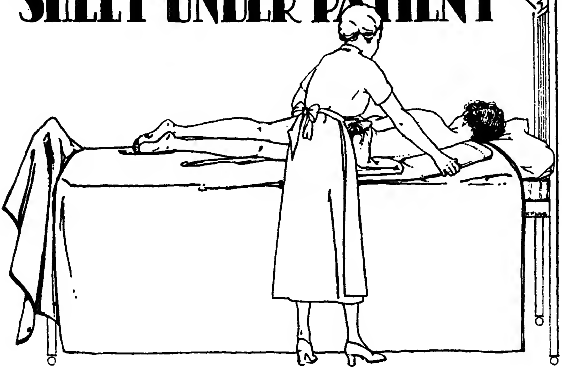
Step 1 PREPARE BED AND PATIENT



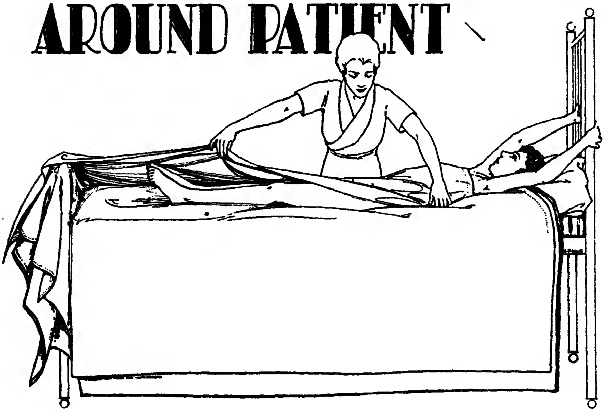
Step 2 FOLD WET AND WRING SHEET

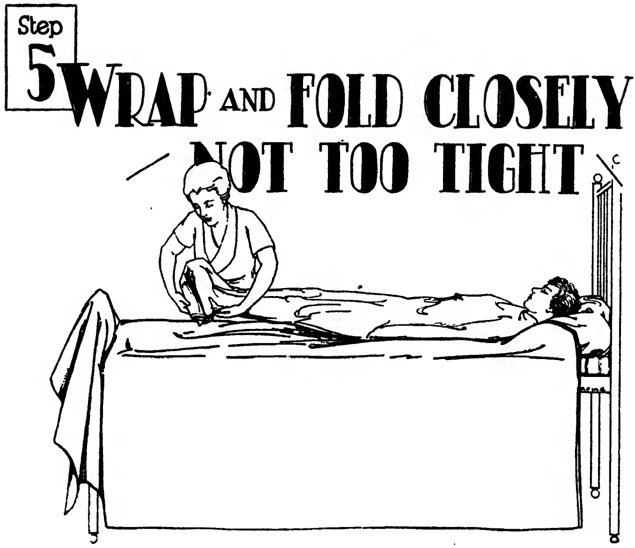


Step 3 UNFOLD AND SPREAD WET SHEET UNDER PATIENT



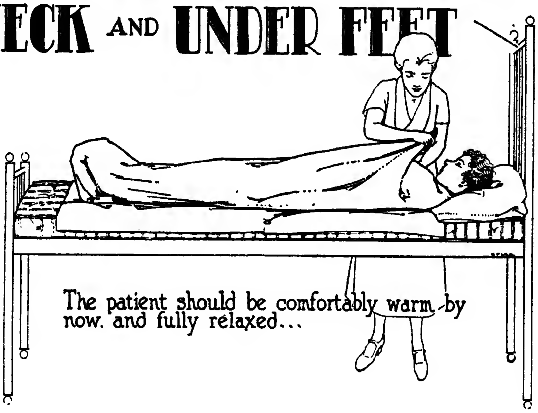
Step 4 TUCK SHEET SNUGLY AROUND PATIENT




Step 5
WRAP AND FOLD CLOSELY
NOT TOO TIGHT


Step 6
WRAP THE BLANKET
SMOOTHLY OVER

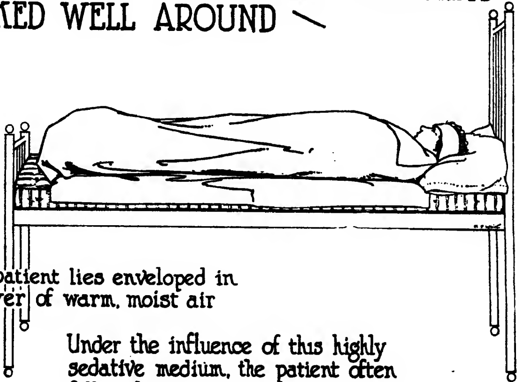
Step 7 FOLD CLOSELY AROUND NECK AND UNDER FEET



The patient should be comfortably warm by now, and fully relaxed...

Step 8 EXTRAS

ONE OR TWO ADDITIONAL BLANKETS TUCKED WELL AROUND



The patient lies enveloped in a layer of warm, moist air

Under the influence of this highly sedative medium, the patient often falls asleep.

To Prepare the Bed.—Spread a rubber sheet over the bed and a blanket over the rubber sheet. Place top edge of blanket so that it will be three inches above the patient's shoulders. If the blankets are small, two may be used placed lengthwise across the bed, overlapping to the approximate size of the wet sheet.

The best results are obtainable when the sheet is folded in such a way that it may be easily spread out under the patient while he is reclining on the bed. Fold the sheet lengthwise and in plait-like folds of six to eight inches wide. Now fold crosswise, forming a bundle 6 to 8 inches wide and approximately 30 inches long. This leaves the sheet in a convenient form to be immersed and wrung out. The sheet is dipped in cold water 60-70 F. and wrung out.

Method of Application.—1. Patient should be in the nude. Work fast and from one side of the bed. Turn the patient on his side and over to the far side of the bed.

2. Lay the folded wet sheet in the middle of the bed one inch below the upper border of the blanket.

3. Unfold the sheet lengthwise (it will look like a white strip dividing the middle of the bed).

4. Unfold half of the sheet crosswise, over the vacant portion of the bed and on top of the blankets.

5. Roll the patient onto the wet, open half and spread the other half over the bed (patient will shudder at first contact with the cold, wet sheet; discomfort should pass quickly).

6. Direct patient to raise arms above head.

7. Fold one-half of sheet closely over patient, high under the arms.

8. Direct patient to lower arms down to sides.

9. Wrap the remaining half of the wet sheet around the patient, upper edge closely surrounding the neck, by making diagonal fold across chest.

10. Press a fold down between the legs and feet and fold lower end under the heels. Be sure the sheet clings snugly to the body everywhere. Sheet should be snug but not binding. Too tight wrapping makes the patient both uncomfortable and apprehensive.

11. Fold one-half of blanket over the patient smoothly around the neck and over the chest. Tuck corner under shoulder and edge under body and legs.

12. Repeat with other half of blanket and tuck lower end under heels. Patient should be getting thoroughly warm now and becoming relaxed. Be sure to guard against cold feet and any prolonged chilling. If feet will not warm up, use hot water bottle. Work fast. A towel may be tucked around the patient's neck for comfort.

The patient may stay in the pack forty-five minutes to one hour.

GENERAL BATHS

Full Hot Bath.—Cecil[3] recommends hot baths to all patients with rheumatoid arthritis as one method of giving them temporary relief of symptoms. His directions for this bath are:

Bath Formula.—The tub is filled with hot water at a temperature of about 100 F.

The patient gets in the bath, and the temperature of the bath is gradually raised to 104 F.

The bath is maintained at this temperature by means of a bath thermometer, and the patient remains in the bath, submerged up to the neck, for from 30 to 45 minutes.

A cold wet towel may be applied to the forehead to lessen the discomfort.

The patient should then be sponged off with cold water or alcohol, wrapped in a light blanket, and allowed to rest for one hour. The mattress should be protected with a rubber sheet.

The patient's stomach should be empty before the bath, but he may take some food, preferably liquids, after the bath is over.

Mustard Bath.—*Indications.*—Collapse or convulsions in infants.

Method of Application.—A mustard paste, free of lumps, is stirred into the tub of hot water. Usually a tablespoon of mustard is used to each gallon of water. A quantity of water sufficient nearly to cover the patient, and at a temperature of 100-105 F., is used. The eyes of the patient should be protected with a towel. Constant friction should be maintained while the patient is in the bath. Patient is removed when skin is red, and is then wrapped in a blanket.

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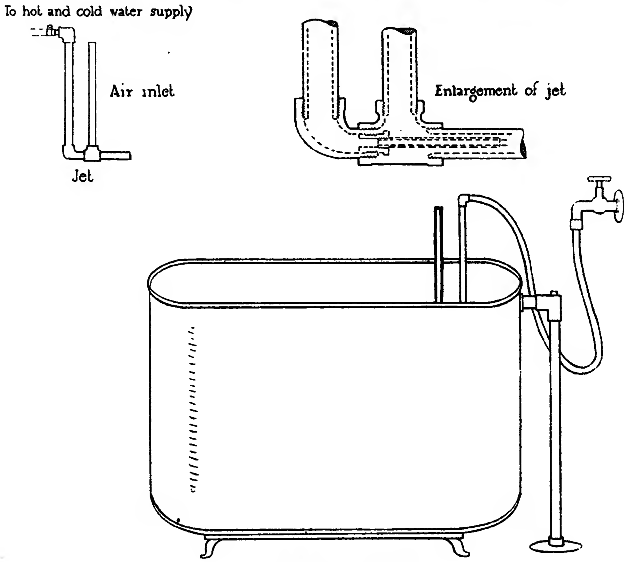
3. Cecil, Russell L.: The Medical Treatment of Chronic Arthritis, J. A. M. A. **103**: 21, 1583-1589 (Nov. 24) 1934.

HOME MADE WHIRLPOOL BATH



Copper Washboiler

INDICATIONS:

1. Edema.
2. Painful cicatrices.
3. Trophic lesions resulting from prolonged suppuration.
4. Preparation for local massage.

SPECIFICATIONS:

Copper washboiler
½", 90° elbow
½", 90° street elbow
½" tee
⅜" to ⅛" bushing
⅛" pipe
Outlet—¾" nipple with locknuts and gasket
½" galvanized iron pipe, enameled white
Street elbow is tapped inside at male end to fit ⅜" bushing
⅛" pipe used for nozzle

A local tinsmith can assemble this unit. A factory product will look better and will be more convenient, but the therapeutic efficacy remains the same in either case.

HYPERTONIC SALT BATH

Indications.—The immediate care of extensive burns for the relief of pain and for the treatment or prevention of shock.

Blair [4] gives the following advantages of the combined use of the saline bath and dry heat in the treatment of wounds:

1. Freedom from painful dressings. For patients who are first seen with badly matted and stuck dressings and clothing, the bath is the best and least painful method of loosening the dressings, and the clothes may be cut away with the patient in the bath.
2. It is probably the least expensive of any and may be carried out in the home.
3. After the routine is once established, nursing care can almost supplant the care of the doctor, except for his daily inspection.
4. This method will encourage active and passive motion and reduce contractures to a minimum.

Apparatus.—The large continuous tub is ideal, but in the home or where this tub is not available, the ordinary bath tub may be used with a support for the head and pads on the bottom of the tub.

Method of Application.—The bath is kept comfortably warm by the continual flow of warm water, sodium chloride is added to keep the solution at approximately 5 per cent. Tub is kept clean but no attempt is made at sterility. Patient is placed in the bath two to three hours daily. During the remainder of the day he lies without dressings on a Bradford frame elevated to allow irrigating fluid to run off the rubber sheet. Electric lamps to supply warmth are placed over the patient on a special frame, and this is covered with sheets. Every hour a pint or more of warm saline solution is poured over the burned areas to prevent crusting.

TECHNIC FOR GENERAL APPLICATIONS

A good "reaction" is the alpha and omega in all cold water applications. Nylin [5] gives a method of finding the patient's reactive capacity. This is done by wrapping a cold, moist towel around the patient's forearm and having the nurse rub this for 10 to 15 seconds.

4. Blair, V. P.: in Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company, Inc., vol. II, chap. 12.
5. Nylin, J. B.: in Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company, Inc., 1933, vol. III, chap. 20.

This local application should produce a good reaction after removal, i. e., the skin becomes red.

In cold water applications the effect of the water depends chiefly on the difference between the temperature of the water and of the skin. Therefore, in this type of application the room should be warm (80 F.). It is often advisable to warm up the patient by some artificial means, such as the drip sheet bath, preparatory to cold water treatment.

Nylin calls attention to the fact that it is a common error to raise the temperature of cold water applications if the patient does not seem to respond to the cold application as readily as expected. In these cases the water temperature should not be changed, but the application should be confined to a smaller area for a shorter period, and the area and time of application gradually increased.

The duration of cold water application is usually short. The cold water should be applied suddenly. The water should be maintained at a definite temperature during the treatment, and if indicated, reduced a degree at every treatment.

Following the application of cold water the patient should be thoroughly dried, and should either exercise or remain in bed covered with blankets to guard against chilling. He should not be allowed to perspire.

In warm applications the mechanical stimulation is usually not important, and often warm applications are given to produce a sedative effect. The temperature of the water in warm applications can be raised. The duration of warm applications is usually prolonged 30 to 60 minutes. A short cold water application immediately following heat applications will lessen the danger of becoming chilled and counteract the feeling of fatigue.

Before using cold or warm applications involving a large part of the patient's body, the patient's head should be cooled by the use of a head compress. This prevents cerebral congestion with its symptoms of headache and dizziness.

The above methods are only a few of the many therapeutic uses of water. These methods require no expensive apparatus, but there is a necessity for exactness of technic in the methods of application if the treatment is to be successful.

COLONIC IRRIGATION

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ROCHESTER, MINN.

Colonic irrigation may be defined as lavage of the large bowel. Usually, copious amounts of a solution at bodily temperature and under low pressure, are introduced and drained through the rectum.

Although the colonic irrigation is frequently looked on by the medical practitioner as a "glorified enema" and is prescribed particularly in the treatment of obstipation, Bastedo[1] stated that "while the ordinary enema is given with the purpose of inducing defecation, the irrigation is administered, not to induce defecation, but to wash out material situated above the defecation area and to lavage the wall of the bowel as high as the water can be made to reach."

It is certain that those who employ colonic irrigation do not place it in the same category with the enema, for it is usually recommended that the bowel be emptied by means of a purgative or enema prior to colonic irrigation. Bastedo, for instance, made the following recommendation as to the procedure to follow prior to irrigating the colon: "If the patient has not defecated, empty the bowels with a plain water enema and wait fifteen minutes for the defecation reflexes to quiet down." The advocates of colonic irrigation are, therefore, of the opinion that treatments should be given in such a manner that the defecation reflex is not aroused.

Among exponents of colonic irrigation, great stress is laid on the fact that the bowel is loaded with bacteria which may produce "toxemia." Pemberton,[2] however, has commented on this as follows:

> For many years the question of "intestinal putrefaction" has occupied a large place in the medical and lay mind, and Cruickshank pertinently points out that the bacterial flora in health, on

1. Bastedo, W. A.: Colon Irrigations: Their Administration, Therapeutic Application and Dangers, J. A. M. A. **98**: 734-736 (Feb. 27) 1932.

2. Pemberton, Ralph: Arthritis and Rheumatoid Conditions, ed. 2, Philadelphia, Lea & Febiger, 1935.

the most varied diets, tends to be proteolytic. He believes that in the last fifteen years no precise work has indicated that, as the result of bacteriologic activity in the intestine, toxic substances are formed which, by gaining entrance into the tissues, induce a state of chronic intoxication. . . . Cruickshank makes the pertinent observation that the intestinal contents should be considered, in one sense of the word, as outside of the body. The mucous membrane protects the body under normal circumstances and an intact mucosa presents an almost impassable barrier even to the products of bacterial growth within an enclosed loop producing intestinal obstruction.

The work of Lloyd Arnold and his associates,[3] however, seems to indicate that animals given yeast or bacteria by mouth or by rectum may show significant absorption of these into the general circulation and even into various organs, from which the organisms can be recovered. In discussing the absorption of yeast from the large intestine Arnold and Fisher conclude that:

1. Yeast is absorbed from the lumen of the colon in greatest numbers at fifteen minutes, diminishing thereafter until none can be demonstrated at the two-hour interval. 2. Egg white mixed with yeast increases the number of yeasts absorbed from the rectum of the dog. 3. A greater number of viable yeast cells can be demonstrated to be present in certain organs after the application of egg white to the duodenal mucosa and yeast introduced into the lumen of the rectum.

VARIOUS OPINIONS AS TO THE VALUE OF COLONIC IRRIGATION

It is extremely difficult to determine the exact sphere of usefulness of the colonic irrigation.

It is unquestionably true that this method of treatment has been outrageously exploited. One can hardly fail to be impressed with the violently opposing views expressed in most of the literature on this subject. One writer, for instance, tells of "phenomenal success in the treatment of many diseases due to consistent and thorough colonic treatments," whereas another bitterly and somewhat facetiously decries the existence of too many "colon filling stations."

One finds that among physicians of unimpeachable medical integrity there are widely divergent views concerning the value of colonic irrigations. For example, Bastedo wrote: "In some circles there has been much

3. Arnold, Lloyd, and Fisher, Virginia: Absorption of Bacteria from the Large Intestine, Proc. Soc. Exper. Biol. & Med. 29: 490 (Jan.) 1932.

criticism of the use of irrigations in 'mucous colitis,' but I have been able to relieve many patients who have been denied the advantage of irrigations by physicians opposed to the procedure." On the other hand, Bargen,[4] in discussing the treatment of ulcerative colitis, said: "Intestinal irrigations usually are not only not helpful but, in the majority of cases, actually are harmful, causing more distress, greater frequency of rectal discharges, and often irritation about the anus."

Again, whereas Bastedo contended that colonic irrigation "leaves the colon more or less empty and contracted and thus exerts a beneficial effect on its blood supply and its tone" and that "the charges that irrigations do harm by removing normal mucus, by lowering the tone of the bowel and by producing colitis are without foundation," Rankin, Bargen and Buie [5] wrote:

> We have judiciously avoided comment on the use of colonic irrigation. Our experience would tend to diminish its use. Almost invariably irrigation with medicated solutions, continued over a time that is long enough to have effect, makes for increased irritation and abdominal discomfort. Indeed, as Friedenwald and Feldman pointed out in 1931, prolonged use of even the simplest enemas is irritating to the colon of dogs. Undoubtedly there are instances in which small enemas of salt water have value in helping to empty the rectum, but intestinal douches, long continued, should be avoided. Tidy has suggested that "medicated enemas continued over a period of time would induce colitis in healthy individuals."

Yet again, Pemberton, in a careful evaluation of the pros and cons of colonic irrigation in the treatment of arthritis, while graphically outlining the shortcomings, makes clear that he uses colonic irrigation in conjunction with colonic massage in some of his cases of arthritis. (In an outline of the chief therapeutic measures utilized in the achievement of results in 200 cases of arthritis—atrophic, hypertrophic and mixed types—colonic massage and irrigation were given in forty cases.) Pemberton stated that:

> One of the most graphic evidences of the value of colonic irrigation is sometimes to be seen in the sudden and sporadic evacuation of a considerable amount of particularly evil-smelling

4. Bargen, J. A.: Chronic Ulcerative Colitis: Trends in Its Present-Day Management, Am. J. Digest. Dis. & Nutrition 1: 190-192 (May) 1934.

5. Rankin, F. W.; Bargen, J. A., and Buie, L. A.: The Colon, Rectum and Anus, Philadelphia, W. B. Saunders Company, 1932, p. 328.

and looking material, in some cases days or even weeks after irrigations have been instituted. This suggests very strongly that a pocket of some kind may have existed which does not empty easily or that a small loop of colon may remain filled an undue length of time. It is the experience of many observers in a number of conditions, including arthritis, that efforts directed at reducing the degree of retention of the contents of the colon may have beneficial consequences. The means to this end may be the ordinary laxatives, though these are not altogether satisfactory and involve certain undesirable effects; or they may be in the nature of irrigation per rectum with various kinds of solutions.

On the other hand Brown,[6] in discussing the treatment of colitis and so-called colitis, stated:

I have tried many solutions for irrigating the colon and have decided that with the exception of a gently administered, warm saline solution, none is of much value; the only value of the saline irrigation is to rid the rectum temporarily of irritating secretions and afford some local comfort by the warmth of the solution.

Again, in discussing diarrhea, he wrote:

Irrigation of the colon has little if any place in the treatment of diarrhea. The occasional use of a small warm saline enema, preferably at bedtime, may be of aid but its constant usage is not advisable.

Lockhart-Mummery,[7] in discussing the treatment of ulcerative colitis stated:

Various substances have been used for washing out the colon. Hurst advised tannic acid, 1 to 2 grains to 1 ounce. Potassium permanganate (1 to 16,000) has also been used. Strong antiseptics must on no account be used, as they will be absorbed. A good solution is from ½ to 1 per cent protargol. Bismuth subgallate (5 per cent) suspension in olive oil is very useful; 8 ounces should be put in and retained if possible. . . . In several cases the best solution for washing the colon is a hypertonic salt solution, 2 drachms of salt to the pint. This tends to increase the flow of lymph from the ulcerated area and to stimulate granulation. . . . The solution should be as nearly as possible at blood temperature, and should be introduced very slowly and without pressure so that spasm is not set up in the colon. . . . To do any good the lavage should be done two or three times a day.

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6. Brown, P. W.: Diagnosis and Treatment of Certain Types of Colitis and So-Called Colitis, M. Clin. North America **16**: 1333-1345 (May) 1933.

7. Lockhart-Mummery, Percy: Diseases of the Rectum and Colon and Their Surgical Treatment, ed. 2, Baltimore, William Wood & Co., 1934.

On the other hand, Bargen,[8] in describing the management of chronic ulcerative colitis, mentioned that:

As in other chronic infectious lesions, i. e., tuberculosis of the lungs, rest of the involved parts is important. For this reason colonic irrigations are rarely indicated.

Stroud,[9] in speaking of colonic lavage in cardiovascular diseases, said: "Since improper intestinal elimination is so common, and since gastro-intestinal symptoms are among the first to appear in the presence of cardiovascular disease, it seems logical that this form of treatment should be of definite value." Weisenburg and Alpers [10] wrote: "High colonic irrigations are of value in some cases of so-called toxic myelitis." These two observations are apparently based on a consideration of colonic irrigation as a means of producing elimination. Such an effect can probably be achieved better by means of the simple enema, proper medication, or modification of the diet.

Morgan and Hite,[11] in discussing colonic irrigations, stated that:

It would be of little use to enumerate the vagaries of this line of medical practice. Suffice to say that at the present time there are two schools of thought relative to the method employed. Members of the first school, which includes many clinicians of wide experience in the treatment of diseases of the alimentary tract, maintain that colonic irrigations and enemas should be restricted quite definitely to a very limited class of colon disorders. They believe that such treatment should be practiced but only for definitely limited periods of time, realizing that a drug or a method of treatment potent for good may be very harmful if carried beyond the limit in quantity or time which the specific ailment calls for. Because hydrotherapeutic measures directed to the colon are likely to fall ultimately into the hands of the unskilled both in and outside the profession, it is vitally necessary that the principle stated above be recognized and accepted at face value. . . . The second school of thought believes in the efficacy of introducing into the colon large quantities of fluid. . . . This method

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8. Bargen, J. A.: Colitis, M. Bull. Vet. Admin. **11**: 1-9 (July) 1934.

9. Stroud, W. D.: Physical Therapy in Cardiovascular Disease, in Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company, Inc., 1932, vol. 1, chap. 13, p. 21.

10. Weisenburg, T. H., and Alpers, B. J.: Physical Therapy in Nervous Diseases, in Principles and Practice of Physical Therapy, 1932, vol. 1, chap. 16, p. 8.

11. Morgan, W. G., and Hite, O. L.: Physical Therapy in Gastro-Intestinal Conditions, in Principles and Practice of Physical Therapy 1932, vol. 1, chap. 21, p. 18.

of treatment does not seem to enjoy the popularity that it did some years ago, having been replaced in a large measure by the medicated enema. With the enema are accomplished the same, if not better, results, and with more facility than with the other method.

TECHNIC

Even among the advocates of colonic irrigation there is great disagreement concerning the technic to be followed, and the technic varies with nearly every individual. There seem to be two main schools of thought concerning the technic of colon irrigation: one is typified by Wiltsie,[12] who recommends the passage of "a fifty-two inch tube through the colon directly into the cecum"; and the other is typified by Bastedo, who said that:

> The passage of such a heavy, stiff piece of hose for more than a few inches, I consider a dangerous procedure. Moreover, the high insertion is unnecessary, for the universal use of the opaque enema in roentgen work has demonstrated beyond question that with a tube inserted 3 or 4 inches into the rectum and a pressure level of 2 feet, the liquid will reach the cecum in from two to five minutes. There is no specific difference, therefore, between a "low irrigation" and a "high irrigation" and such misleading terms should be abolished.

Bastedo's viewpoint seems more acceptable and it is probable that if colonic irrigations should be indicated, the tube should not be introduced for more than 4 to 6 inches (10 to 15 cm.). The myth of the so-called high colonic irrigation has been exploded, and this term should be abandoned.

In the few cases in which colonic irrigation may be indicated it is probably best to follow one of the two methods described by Bastedo as follows:

> *The One-Tube Method.*—This involves filling the colon to capacity through a single tube and then allowing the liquid to run out through the same tube, the process being repeated a number of times. The tube most favored is velvet-eyed with closed end, number 34 French, and is inserted about six inches. As demonstrated by roentgenograms, when the ordinary colon tube is passed beyond six or eight inches, it coils up in the upper rectum and, no matter how much of the tube is inserted, it rarely enters the descending colon. There is therefore no benefit to be derived from passing a long colon tube 18 to 20 inches to form such a coil in the rectal ampulla. . . .

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12. Wiltsie, J. W.: Colonic Therapy: A Method of Special Drainage, Arch. Phys. Therapy 12: 292-295 (May) 1931.

The Two-Tube Method.—This employs separate inflow and outflow tubes. . . . For the inflow I use a soft rubber velvet-eyed catheter, number 20 to 24 French, inserted from 5 to 6 inches and for the outflow, a velvet-eyed closed-end rectal tube (or stomach tube) number 30 or 32 French, inserted from 3 to 4 inches.

Bastedo listed the following instructions for the nurse-technician administering the irrigation:

1. If the patient has not defecated, empty the bowels with a plain water enema and wait fifteen minutes for the defecation reflexes to quiet down.

2. For the first gallon have the patient lie on the left side with the knees drawn up. After that have the patient lie on the back.

3. Hang the reservoir so that its midlevel is not more than two feet above the rectum.

4. Having freely lubricated the tubes with white petrolatum, have the patient bear down as at stool and insert the inlet tube five or six inches, allowing the water to flow during its insertion. Then insert the outlet tube three or four inches.

5. Use plain water at or just above body temperature, and let it run slowly to avoid arousing the defecation reflexes.

6. If the outlet tube becomes plugged, inject a little water through it with a hand bulb. If this does not clear it, withdraw it without disturbing the inlet tube, clean it and reinsert.

7. Terminate the irrigation when convinced that the colon is clean or when you think the treatment has been sufficiently prolonged. We expect an irrigation to consume from six to ten gallons and to take nearly an hour.

8. After the irrigation, have the patient empty the bowels into the toilet. Examine this return before the toilet is flushed.

9. Report particularly on the various odors and on the amount and character of the mucus, feces and recognizable food particles in each gallon of the return.

Rest after treatment is important and needs definite emphasis. The patient should, as a rule, be permitted to rest in the prone position for about an hour following a colon irrigation.

Solutions.—These are usually either mild antiseptics or alkalinizing or acidifying solutions. Since altering the reaction of the contents of the colon is apparently a futile procedure, and since "the Dragstedts and Nisbet . . . showed the impossibility of sterilizing the intestine by ordinary antiseptics," none of these solutions can be considered very useful.

Ordinary tap water or physiologic solution of sodium chloride at bodily temperature is probably more satisfactory. If colonic irrigation is to be used, the latter is recommended in preference to antiseptic solutions. The use of very hot solutions to destroy intestinal parasites is of doubtful value.

Equipment.—Elaborate devices for the administration of colonic irrigation have been manufactured. These devices usually have one or more adjustable irrigation tanks attached to a table, equipped with various gadgets to make it appear imposing. There may be a built-in hopper, and an elaborate system of petcocks, water connections, flushing devices, solution warmers, or tube sterilizers, all as a rule finished off with an excessive amount of shining chromium. It is interesting to note that, strangely enough, there have been and are being issued innumerable patents by the United States Patent Office for these devices. A great many hospitals have equipped themselves with some such elaborate device. But the work can be done just as easily with (1) an ordinary treatment table, (2) a plain glass irrigation jar on a stand, (3) a rectal tube and a Y tube with two clamps, and (4) a large closed jar or an ordinary hopper to receive the return flow. If, therefore, colonic irrigations are to be given at all, the latter simple arrangement is recommended.

UNTOWARD RESULTS

Colonic irrigations may cause "distress, greater frequency of rectal discharges and often irritation about the anus." [4] Colonic irrigations may disturb the chronic ulcer of the bowel by mechanical irritation, when "as in other chronic infections rest is important." [8] They may produce "nausea with a feeling of pressure in the epigastric region; undue abdominal distention; cramps; anal irritation; and, following the irrigation, a feeling of weakness." [1] Pemberton [13] wrote:

> I have seen two deaths from intussusception or volvulus followed by obstruction caused by colonic irrigation, in patients supposedly accustomed to it. I have also seen two other attacks suggesting obstruction, from the same procedure carried out by skilled hands.

13. Pemberton, Ralph: Personal communication to the author.

Bastedo wrote of the mishaps and dangers as follows:

> The most common mishap reported is bleeding from the rectum. In examining these patients I have found that the blood usually comes from hemorrhoids, though occasionally from a fissure or ulcer. In two instances I have found a torn rectal valve and in several others an injured or severed polypus. These severe traumas resulted from the use of too stiff a tube or a tube with a sharp-edged terminal opening. Dr. J. M. Lynch tells me of perforation of a sigmoid diverticulum by the irrigation tube.

COMMENT

With such a bewildering array of conflicting opinions from authoritative sources, the reader can readily understand the difficulty in giving a proper evaluation of of colonic irrigation. When colon irrigation is made available to the average physician as part of the general service of the average hospital, with no compulsion or restriction as to the use of this method of treatment, he rarely finds occasion to order a colonic irrigation.

This can probably best be accomplished by describing the use of colonic irrigations in two hospital departments of physical medicine. Each of these departments averaged more than 500 patient visits per month. Each department was equipped with a suitable device for giving colonic irrigations and each was staffed with skilled technicians capable of giving satisfactory treatments under medical supervision. The staffs of these hospitals were fully aware of the availability of these devices for both ward and private patients.

Bastedo stated that colonic irrigations are indicated "in chronic states of the bowel, such as are encountered in 'mucous colitis,' intestinal putrefactive toxemia, and in cases in which a focus of infection is believed to reside in the bowel, as in certain cases of rheumatism, neuritis, secondary anemia, and sundry run-down conditions." However, the observations of Bargen [4] tend to show that colonic irrigations are usually contraindicated in both "mucous colitis" and "ulcerative colitis" and the consensus among experts in the field would tend to support Bargen's contentions.

In "intestinal putrefactive toxemia" the experience of Cruickshank would tend to show that colonic irrigation is a little needed procedure. In this connection Pemberton, in discussing the rôle of colonic irrigation

in arthritis and the relationship between putrefactive and fermentative bacteria, said:

> The writer knows as yet of little precise evidence, however, to show that a change from putrefactive to fermentative types of flora has led, per se, without the influence of other concomitant factors, to betterment of the arthritic process, though he has endeavored to induce such changes frequently.

Discussion then narrows almost entirely to the possible usefulness of irrigation in the treatment of focal infection in the colon or in the removal of impacted or pocketed fecal masses in the large bowel. Cruickshank's observations would tend to minimize the contention that the colon is often a focus of infection, and Pemberton, in discussing the presence of one infecting organism (the streptococcus) in the colon wrote:

> We are in a position today to state that it may be present in the feces in apparent health. It would be philosophically unsound, however, to postulate that it could do no harm.

Nevertheless, since it is known that it is impossible to sterilize the large bowel by means of medicated solutions, the usefulness of irrigations for supposed focal infections in the colon remains controversial. Yet there is apparently sufficient clinical data for one to state that colonic irrigations are of value in the treatment of arthritis. As Pemberton expressed it:

> In any event, it is thoroughly determined that in a certain proportion of arthritics, processes of a vague and, as yet, unmapped nature operate unfavorably within the intestinal canal and particularly the colon, apparently apart from any association with the organisms causing focal infection in the ordinary sense of the word. It is reasonably certain that a variety of factors contributes to the intestinal origin of arthritis, and the dispassionate position to be taken today is that which recognizes the several possibilities involved but does not commit itself unduly to any single one.

It is possible that the use of copious amounts of fluid to wash out retained fecal material above the defecation area of the large bowel is occasionally indicated. Certainly it is an abnormal procedure, and other methods of treatment (particularly dietetic management) which tend to restore normal intestinal function would seem more desirable. It may at times be advisable to treat constipation in this manner in the hope of removing retained fecal material. It seems obvious, however,

that oft-repeated or routine administration of colonic irrigations is to be strongly deprecated. Even occasional irrigations are rarely indicated.

SUMMARY

The colonic irrigation is not to be considered as a massive enema but as a lavage of the colon above the area of defecation, administered under low pressure so that the defecation reflex is not stimulated. One must also consider that in conjunction with the lavage there are possibly other factors present (such as pressure, temperature, motion and osmosis) which may act to influence normal and disturbed physiologic processes in the gastro-intestinal tract. Copious amounts of fluid are usually employed. Antiseptic solutions or solutions which tend to acidify or alkalinize the colonic contents are of little or no value. Tap water or physiologic solution of sodium chloride seems, as a rule, more satisfactory.

The term "high colonic irrigation" should be abandoned. The attempt to introduce a long stiff tube into the cecum is dangerous and usually fails, the tube coiling in the rectum. If the tube is introduced only three or four inches, under ordinary conditions the fluid will reach the cecum in from two to five minutes anyway.

Elaborate apparatus is not necessary for the administration of colonic irrigations.

Colonic irrigations have been greatly exploited.

The oft-repeated or routine administration of colonic irrigation is to be strongly deprecated.

Whereas an occasional series of colonic irrigations may be indicated for the treatment of unfavorable conditions within the intestinal canal, as for example at times in arthritis, or for the removal of retained fecal material from the colon, such indications are relatively infrequent.

DIRECT CURRENT APPLICATIONS AND ELECTRICAL STIMULATION OF MUSCLE

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Both direct current and alternating current have a very definite field of usefulness in the treatment of properly selected pathologic conditions. Their use is dependent on well known physical laws.[1] There are two types of generators manufactured; one generator produces direct current exclusively, whereas the other generates both direct and alternating current. Turrell,[2] Kovacs,[3] Krusen [4] and Osborne and Holmquest [1] have described the various types of currents and generators in detail.

THE DIRECT CURRENT

The flow of an electric current may be unidirectional or alternating. A direct or galvanic current as employed in medicine is a unidirectional continuous current of constant intensity. Other terms used to designate this current in medicine are continuous, constant, unidirectional and currents of low tension. It would seem highly desirable in the interest of uniformity of nomenclature and accuracy of description to adopt the term "direct current" to conform with internationally accepted electrical nomenclature.

The direct current, when passed through an electrolyte, presents positive and negative polarity effects. The reactions found at the positive pole are diametrically opposed to those found at the negative pole. The rationale for the use of the direct current is dependent

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1. Osborne, S. L., and Holmquest, H. J.: Technic of Electrotherapy and Its Physical and Physiological Basis, Springfield, Illinois, Charles C Thomas, 1944.
2. Turrell, W. J.: The Physiologic and Therapeutic Action of Interrupted Currents of Low Frequency and of the Constant Current, in Principles and Practice of Physical Therapy, edited by Mock, Pemberton and Coulter, Hagerstown, Md., W. F. Prior Company, Inc., 1932, vol. 3, chapters 9 and 10.
3. Kovacs, Richard: Electrotherapy and Light Therapy, Philadelphia, Lea & Febiger, 1942.
4. Krusen, F. H.: Physical Medicine, Philadelphia, W. B. Saunders Company, 1941.

on these polar reactions.[1] The greatest field of usefulness is the introduction of ions or the exchange of ions within the tissues for definite therapeutic effects by means of the direct current. This procedure is known as "ion transfer." An active electrode is saturated with the required electrolytic solution, applied to the tissues and connected to the positive pole, if the positive ions are to be introduced, and to the negative pole, if the negative ions are to be used. The velocity of the ions employed and the circulating blood will limit the depth of penetration as well as the degree of concentration in the tissues. The conductivity of an electrolyte depends not only on the number of ions present but also on their velocity. Owing to the far higher velocity of the tissue ions and their greater number, the foreign ions—the ions to be introduced—cannot contribute appreciably to the flow of current in the deeper tissues. The foreign ions introduced through the skin lose their electrical charge and precipitate as soluble or insoluble compounds in the superficial tissues. The speed of the circulating blood will also tend to sweep away quantities of these ions into the general circulation. However, in spite of these limitations the procedure is of value because the ions will penetrate to a greater depth into the tissues than that usually secured by topical applications of the same remedies. Moreover, for the use of such substances as mecholyl (acetyl-beta-methylcholine chloride), ion transfer is a much safer procedure than the use of hypodermic injections of the same drug. Ion transfer is also known as ionic medication, ionization and iontophoresis. It is preferable and is accurately descriptive to speak of this electrochemical phenomenon as "ion transfer."[1]

A large number of clinical reports have been written during the last ten years on the use of ion transfer. Particular attention has been given to the parasympathetic stimulating drugs such as histamine and mecholyl. Opinion is divided as to which of these vasodilating drugs is the more effective. Both have been extensively used: the Kovacses,[5] Kling,[6] Mackenna.[7] Boyd,

5. Kovacs, Richard, and Kovacs, Joseph: Mecholyl Iontophoresis, Arch. Phys. Therapy **15**: 593 (Oct.) 1934; Iontophoresis of Acetyl-Beta-Methyl-Choline Chloride in the Treatment of Chronic Arthritis and Peripheral Vascular Disease, Am. J. M. Sc. **188**: 32 (July) 1934.

6. Kling, D. H.: Histamine Iontophoresis in Rheumatic and Peripheral Circulatory Disturbances, Arch. Phys. Therapy **16**: 466 (Aug.) 1935.

7. Mackenna, F. S.: Histamine Ionization in Rheumatism and Allied Conditions, Lancet **1**: 364, 1936.

Osborne and Markson [8] and Baker [9] have used one or both of these drugs in the treatment of arthritis by means of ion transfer. A joint Council article [10] states that mecholyl ion transfer may be used with considerable benefit in some cases of chronic ulcers, Raynaud's disease, scleroderma and certain vasospastic conditions of the extremities. Rosenthal [11] treated 50 hospitalized patients with severe pelvic infection and 39 patients with myomas of the uterus associated with pelvic inflammatory disease, degeneration of myomas or both. He reported that the results of treatment with mecholyl in tubo-ovarian infection, while often good, were not sufficiently good to warrant use of this therapy. His best results, he states, were obtained in cases of massive cellulitic infection of recent origin which failed to yield to ordinary treatment. He also writes that the preoperative preparation of myomas associated with pelvic inflammatory disease may often be shortened with this method and the operative risk decreased. Johnson and Dolan [12] treated 43 patients with sciatic neuritis and found mecholyl ion transfer a very effective treatment. Hummon [13] states that he has treated 1,000 patients with histamine ion transfer over a period of five years and has found it particularly effective in reducing swelling and echymosis of acute injuries.

Boyd [14] compared the sodium sulfathiazole concentration that could be secured in the cornea and aqueous humor by using in one instance ion transfer and in the other a corneal bath. He found that he was able to secure three times the degree of sodium sulfathiazole concentration when he used ion transfer as contrasted with the corneal bath. For the ion transfer he used a 5 per cent solution of the drug and a current of 1 milliampere for two minutes. When he used a current of 2 milliamperes the concentration of sodium sulfathiazole

8. Boyd, D.; Osborne, S. L., and Markson, D. E.: Observations on the Use of Acetyl-Beta-Methylcholine Chloride in Chronic Arthritis, Ann. Int. Med. **10**: 728, 1936.

9. Baker, Frances: Indications and Technic of Iontophoresis, Arch. Phys. Therapy **20**: 197, 1935.

10. Klump, T. G., and Carter, Howard A.: Ion Transfer (Iontophoresis), J. A. M. A. **117**: 360 (Aug. 2) 1941.

11. Rosenthal, A. H.: The Treatment of Pelvic Infection by Iontophoresis of a Choline Compound, Am. J. Surg. **54**: 639, 1941.

12. Johnson, C. E., and Dolan, T. O.: Treatment with Acetyl-Beta-Methylcholine Chloride, M. Bull. Veterans Administration **18**: 420, 1942.

13. Hummon, I. F., Jr.: Histamine Ion Transfer, a Five Year Evaluation, Arch. Phys. Therapy **25**: 212, 1944.

14. Boyd, J. L.: Sodium Sulfathiazole Iontophoresis, Arch. Ophth. **28**: 205, 1942.

increased ten times in the cornea and nine times in the aqueous humor. He states that no vascular damage was observed with the use of a current that produces a satisfactory sulfathiazole concentration in the cornea and in the aqueous humor, that is, a concentration consistent with optimal bacteriostatic effect.

The use of ion transfer of salts of heavy metals in gynecology is not as prevalent as it was several decades ago. Few reports appear in the recent literature. From theoretical considerations of the action of the electric current there is no doubt that coagulation of the mucous membranes can be accomplished by this procedure. The value of the method would depend on its safety, effectiveness and adaptability as compared with other methods used in the same type of case. Ion transfer of copper salts in cervicitis is a method of coagulation which cannot be justly evaluated until further reports reveal how the results obtained by that method compare with those obtained in similar cases treated by surgical methods, the cautery or local drug cauterization.

In otorhinolaryngology the same type of therapy has not only been widely used in recent years but has found favor in the reports of many authors. The method is used in hay fever and allergic conditions, hyperesthetic rhinitis, intumescent rhinitis and chronic otorrhea. In rhinolaryngology, Hollander,[15] the Alexanders,[16] Volk,[17] Alden,[18] Demetriades,[19] Franklin,[20] Warwick,[21] Stovin,[22] Hurlburt,[23] Miller,[24] Cottle,[25] Tobey [26]

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15. Hollander, A. R.: Ionization as a Prolonged Palliative in Vasomotor Rhinitis, Arch. Otolaryng. **21**: 448 (April) 1935; Influence of Ionization on Vasomotor Rhinitis, Illinois M. J. **214**: 244 (Dec.) 1935.
16. Alexander, H. L., and Alexander, J. H.: Ionization of Nasal Mucous Membranes, J. Allergy **6**: 240 (March) 1935.
17. Volk, L. D.: Iontophoresis in Hay Fever and Allergic Conditions, Laryngoscope **45**: 607 (Aug.) 1935.
18. Alden, A. M.: The Response of Allergic Phenomena to Ionization, Laryngoscope **45**: 620 (Aug.) 1935.
19. Demetriades, T. D.: Zur Behandlung der vasomotorischen Störungen der Nase durch Iontophorese, Monatschr. f. Ohrenh. **61**: 524 (May-June) 1927.
20. Franklin, Philip: Treatment of Hay Fever by Intranasal Zinc Ionization, Brit. M. J. **1**: 1115 (June 27) 1931.
21. Warwick, H. L.: Treatment of Hay Fever and Its Allied Conditions by Ionization, Laryngoscope **44**: 173 (March) 1934.
22. Stovin, J. S.: Treatment for Atrophic Rhinitis, Arch. Otolaryng. **14**: 618 (Nov.) 1931.
23. Hurlburt, J. A.: Treatment of Hay Fever by Ionization Method, Wisconsin M. J. **34**: 93 (Feb.) 1935.
24. Miller, Clifton M.: Hyperesthetic Rhinitis (Hay Fever): Treatment by Zinc Ionization, Virginia M. Monthly **62**: 11 (April) 1935.
25. Cottle, M. H.: Nasal Ionization by a New Simplified Technic, Arch. Phys. Therapy **16**: 405 (July) 1935.
26. Tobey, H. G.: Experiences in Ionization of the Nasal Mucous Membrane, New England J. Med. **213**: 230 (Aug. 1) 1935.

and Garfin and Pearl [27] feel that this method used on the nasal mucous membranes gives satisfactory results in the treatment of hay fever and rhinitis of vasomotor origin. Fibrosis of the submucosa of the nasal mucous membranes without permanent destruction of the surface epithelium has been produced by ion transfer of zinc salts. This has been demonstrated histologically in both human and animal experiments.[18]

It is debatable whether effects are produced other than a coagulation of the nasal mucous membrane. Schall [28] states that Palmer treated a group of 30 patients with vasomotor rhinitis by a local application of concentrated phenol. The immediate effect of this treatment was exactly that which was obtained by the galvanic instrument of Warwick, in that the mucous membrane showed a grayish white discoloration followed by edema and obstruction with hypersecretion. Palmer had excellent cooperation from his patients, as they voluntarily permitted biopsies to be taken. The microscopic examination revealed that there was an increase in the connective tissue of the tunica propria with a diminution of the edema and vascularity. Of 30 cases treated by Palmer, 24 showed definite improvement and 12 were free from symptoms for periods of from three to nine months. Fenton [29] bluntly states that ion transfer as such does not do anything more than damage the mucosal tissues of the sinuses. It is pointed out as essential by the majority of these workers that good results are secured only if patients likely to benefit from this type of treatment are selected. Hollander [30] believes that the introduction of zinc ions in allergic rhinitis is palliative and not curative. According to Hollander the results obtained in seasonal hay fever are less satisfactory, whereas in nonallergic nasal cases the results are excellent.

Duke [31] tends to throw doubt on claims made for the method. The work of the Alexanders [16] suggests that

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27. Garfin, S. W., and Pearl, S. L.: Ionization in the Treatment of Hay Fever and Allied Conditions, New England J. Med. **214**: 244 (Feb. 6) 1936.

28. Schall, L. A.: Progress in Laryngology, New England J. Med. **213**: 574 (Sept. 19) 1935.

29. Fenton, R. A.: Discussion on Ionization in Mucosa of Frontal Sinuses of Dogs, Tr. Am. Laryng. Assn., 1934, p. 48.

30. Hollander, A. R.: Intranasal Zinc Ionization, Arch. Phys. Therapy **15**: 581 (Oct.) 1934; Further Studies with Zinc Ionization in Nasal Allergy, ibid. **16**: 359 (June) 1935.

31. Duke, W. W.: Allergy as Related to Otolaryngology, Arch. Otolaryng. **22**: 638 (Nov.) 1935.

the relief obtained by ion transfer is due to the mechanical removal of antibodies from the nasal mucous membranes, and they further contend that the results are better if patients have no reagins in the blood. However, methods of treatment other than ion transfer used by allergists are neither uniformly satisfactory nor entirely free of danger. The conclusion reached by Hurd [32] concerning the entire question of this method in rhinolaryngology is conservative but not destructive. He is of the opinion that the method has not been used long enough at the present time for determination of its actual value and dangers. Ramirez [33] has reported disappointing results obtained by this procedure in the treatment of hay fever, but in the treatment of nonspecific perennial vasomotor rhinitis his results have been satisfactory.

In otology, according to Hollander,[34] sufficient evidence on the use of this method is not available to place it on a firm scientific basis, although for selected patients he admits it may be valuable. It seems to be of most value in the treatment of chronic purulent otitis media or chronic otorrhea. Favorable reports have been made by Friel,[35] Granberry,[36] MacFarlan,[37] Jobson [38] and many others. Lierle [39] does not give the favorable and often enthusiastic report made by some of the other investigators. In the entire field of otorhinolaryngology, further controlled research should enable us to evaluate accurately this electrotherapeutic procedure.

The direct current may produce reflex vasodilatation by its stimulating action on sensory nerve endings. It may thus act on the skin like other counterirritants such as a blister or ultraviolet radiation. Some believe that the direct current is superior to most counterirritants

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32. Hurd, L. M.: A Critical Analysis of Methods of Physical Therapy in Rhinolaryngology, Laryngoscope **45**: 468 (June) 1935; Treatment of Hay Fever and Hyperesthetic Rhinitis by Ionization, Arch. Otolaryng. **22**: 416 (Oct.) 1935.

33. Ramirez, M. A.: Disappointing Results from the Ionization Treatment for Hay Fever, J. A. M. A. **106**: 281 (Jan. 25) 1936.

34. Hollander, A. R.: Scientific Status of Physical Therapy in Otology, Laryngoscope **45**: 471 (June) 1935.

35. Friel, A. R.: Notes on Chronic Otorrhea, New York, William Wood & Co., 1929.

36. Granberry, C. E.: Zinc Ionization in the Treatment of Chronic Purulent Otitis Media, New Orleans M. & S. J. **78**: 157 (Sept.) 1925.

37. MacFarlan, Douglas: Ionization: Circuit Plans for an Inexpensive Unit, Arch. Otolaryng. **21**: 456 (April) 1935.

38. Jobson, T. B.: Zinc Ionization in Tympanic Sepsis, J. Laryng. & Otol. **41**: 383 (June) 1926.

39. Lierle, D. M.: Underlying Factors in the Zinc Ionization Treatment of Middle Ear Infections, Ann. Otol., Rhin. & Laryng. **41**: 359 (June) 1932.

because it can produce a gradual and more constant action on the skin without destructive effects.

Electrolysis is used extensively in dermatologic practice. For hypertrichosis, exceedingly fine needles specially made for the purpose are obtainable. Some physicians prefer to use multiple needles. However, the majority prefer to use a single needle. The technical procedure for this has been well outlined by Cipollaro.[40]

MacKee [41] considers electrolysis to be the best treatment for the spider nevi. All that is necessary, he states, is to puncture the central dark spot with the point of the needle. There should be no scar. He states that in telangiectasis, when the vessels are small and not too numerous, they may be occluded as a result of electrolysis, and that if this is carefully done there will be little or no scarring.

The direct current may be used to produce contraction of either a normal or a denervated muscle. A circuit breaker "make and break" key is connected to a source of direct current, and when the current circuit is closed the muscle contracts. Such a muscle contraction is sharp and shocklike, single and unsustained, and does not simulate the normal voluntary action.

Blonder and Davis [42] have reported that the galvanic falling test with the use of the balance board is an accurate, simple clinical test for determining the integrity of the vestibular postural arc.

MUSCLE STIMULATING CURRENTS

Much confusion exists with regard to the use of electrical stimulation in the treatment of the denervated muscle. There is disagreement as to the value of such therapy,[43] although most of the more recent evidence is in its favor.[44] The type of stimulating current to be

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40. Cipollaro, A. C.: Electrolysis: A Discussion of Equipment, Method of Operation, Indications, Contraindications and Warnings Concerning Its Use, J. A. M. A. **111**: 2488 (Dec. 31) 1938.

41. MacKee, G. M.: The Treatment of Skin Diseases by Physical Therapeutic Methods, J. A. M. A. **98**: 1646 (May 7) 1932.

42. Blonder, E. J., and Davis, Loyal: The Galvanic Falling Reaction in Patients with Verified Intracranial Neoplasms, J. A. M. A. **107**: 411 (Aug. 8) 1936.

43. Grodins, F. S.; Osborne, S. L., and Ivy, A. C.: Present Status of Electrical Stimulation of Denervated Muscle, Arch. Phys. Therapy **23**: 729, 1942.

44. Fischer, E.: Effect of Faradic and Galvanic Stimulation on Course of Atrophy in Denervated Skeletal Muscles, Am. J. Physiol. **127**: 605, 1939. Solandt, D. Y.; De Lury, D. B., and Hunter, John: Effect of Electrical Stimulation on Atrophy of Denervated Skeletal Muscle, Arch. Neurol. & Psychiat. **49**: 802 (June) 1943. Hines, H. M.; Thomson,

(Footnote continued on next page)

used in any given case is not well understood. Recently Osborne, Grodins, Mittlemann, Milne and Ivy,[45] writing on the rationale for electrical stimulation in denervated muscle, have reported the design of an experimental apparatus and the physiologic principles on which it is based.

The object of electrical muscle stimulation should obviously be to produce a muscular contraction which simulates a normal voluntary contraction. It is well known that a normal voluntary contraction is not a simple twitch but rather a smoothly graded tetanus.

A skeletal muscle is composed of a number of individual motor units. Grading of voluntary muscular contraction is accomplished in two ways: (1) by an increasing number of motor units becoming active and (2) by an increasing frequency of response of individual units producing a more and more completely fused tetanus. The first is normally accomplished by an increase in the number of nerve fibers discharging; it can be accomplished artificially by an electrical stimulus of gradually increasing intensity. The second is normally accomplished by an increased frequency of discharge of individual neurons; it can be accomplished artificially by an increase in the frequency of electrical stimulation.

According to Grodins, Osborne and Ivy,[43] the ideal current for stimulating the normal skeletal muscle should consist of a series of pulses of instantaneous rise which gradually increases in intensity from threshold to maximal and in frequency from zero to 100 per second. For denervated muscle the ideal current would be of similar form, but the individual pulses would have to be of longer duration, of lower frequency and perhaps of gradual rise. Thus, according to these authors the current best suited for muscle stimulation is a modulated alternating current with a carrier frequency of 50 cycles per second for the normal muscle and a carrier frequency of 5 to 25 for the denervated muscle.

J. D., and Lazere, B.: Physiological Basis for Treatment of Paralyzed Muscle, Arch. Phys. Therapy **24**: 69, 1943. Grodins, F. S.; Osborne, S. L.; Arana, S.; Johnson, F., and Ivy, A. C.: The Effect of Appropriate Electrical Muscle Stimulation on Atrophy of Denervated Skeletal Muscle in the Rat, Grodins, F. S.; Osborne, S. L.; Arana, S.; Johnson, F., and Ivy, A. C.: Am. J. Physiol. **142**: 222, 1944.

45. Osborne, S. L.; Grodins, F. S.; Mittlemann, E.; Milne, W. S., and Ivy, A. C.: Rationale for Electrodiagnosis and Electrical Stimulation in Denervated Muscle, Arch. Phys. Therapy **25**: 338, 1944.

To be beneficial, electrical muscle stimulation must fulfil the following conditions: (1) A modulated alternating current with the proper carrier frequency must be used, (2) vigorous exercise is essential—work must be done—(3) long periods of stimulation are necessary, (4) treatment must be started early and (5) a tetanic type of contraction must be obtained to secure maximal tension of the muscle fibers stimulated. It is quite possible that the nature of the response produced by electrical stimulation of muscle [45] has an important bearing on the success or failure of the therapy.

The only requirement of the electrical current when using it for the treatment of the denervated muscle, Pollock [46] states, is that it will produce a contraction of the denervated muscle. He also states that obviously this cannot be brought about by stimulation with the tetanizing currents at present available, as the duration of each shock is too short in relation to the changed chronaxie of the denervated muscle. Therefore, Pollock believes, a direct current must be used. The direct current, he writes, may be given as an interrupted direct current or in the form of a sinusoidal current.

The term sinusoidal can be very misleading, and unless the current does conform to the mathematical sine law the term should not be used. The so-called "slow smooth sinusoidal current" has been used for stimulation of the denervated muscle. It has been suggested that this term be changed for the more descriptive term of "surging uninterrupted direct current with alternate polarity." [1]

Electrical stimulation of muscles must be employed in conjunction with other valuable physical therapeutic agents such as dry heat, massage, physiologic rest and reeducational exercises. In poliomyelitis the selection of the current to be used is most important. For a muscle with some of its fibers denervated and other fibers with the nerve supply intact, care must be taken to stimulate only those fibers that are denervated, and unless this can be accomplished it might be safer not to use electrical stimulation.

In peripheral nerve injuries, electrical stimulation by providing muscular exercise may prevent atrophy and fibrosis of the muscle while the nerve is regenerating;

46. Pollock, L. J.: Principles and Practice of Physical Therapy, **2**: 7, 1933.

but further experimental work is necessary. Bourbon [47] advises the use of electrical stimulation in the treatment of facial paralysis.

Osborne and Holmquest [1] have outlined a treatment for paralysis of the laryngeal muscles occurring as a sequel to diphtheria or thyroidectomy.

Any form of tetanizing current can be used to stimulate muscles that have poor tone as long as they have a normal nerve supply. Either one of two methods of application may be employed. One technic produces repeated individual shock-like muscular contractions, while the other produces a contraction which may be graduated in intensity from zero to a maximum. At one time the faradic current—one form of tetanizing current—was used extensively in exercising muscles of patients who were undergoing treatment for the psychoneuroses. Active exercise and massage would probably have been of greater value. Faradic stimulation is also used in the treatment of hysterical paralysis. In conjunction with direct current the faradic current is used to determine whether the reaction of degeneration is present and, if present, its extent. Turrell [2] has emphasized the danger that can arise from use of the faradic current because of its tetanizing effect.

Electrical stimulation of muscle is advocated by Osborne and Holmquest [1] in the treatment of upper motor neuron lesions, provided treatment is directed to the less spastic muscles. Electrical stimulation has been advocated during the early stage of hemiplegias when the muscles are flaccid. Weisenburg and Alpers [48] state that it is of little use in combined cord sclerosis, progressive muscular atrophy and myasthenia gravis. In cerebrospastic paralysis Ryerson [49] and Gordon and Brown [50] are of the opinion that any form of electrical stimulation is contraindicated.

47. Bourbon, O. P.: Facial Paralysis, Arch. Otolaryng. **22**: 285 (Sept.) 1935.

48. Weisenburg, T. H., and Alpers, B. J.: Physical Therapy in Nervous Diseases, in Principles and Practice of Physical Therapy, vol. 1, chapter 16.

49. Ryerson, E. W.: Physical Therapy in Cerebral Spastic Paralysis, in Principles and Practice of Physical Therapy, vol. 1, chapter 9.

50. Gordon, R. G., and Brown, M. F.: Physical Treatment of Paralysis in Children, Brit. J. Phys. Med. **9**: 189 (Feb.) 1935.

PHYSICAL CHARACTERISTICS OF ELECTRICAL ENERGY USED IN THERAPY

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INTRODUCTION

In view of the knowledge now available, nothing short of a two volume work can cover completely the field of electricity as it is applied to the practice of physical therapy. This chapter, written for the busy physician and not for the physicist, is intended to discuss briefly some of the more common electrical phenomena the physician practicing physical therapy is likely to encounter in his everyday work. "Fundamental truths" in physics are usually expressed in mathematical notation. In this article mathematical expressions are not used. Formulas, mathematical deduction and reasoning, and sample problems are deliberately left out. The reader is reminded, however, that a full knowledge of physics is not possible without the mathematical approach. The many references found at the conclusion of each section will refer the reader to more complete treatises on the subjects under discussion.

ELECTRIFICATION

Physicians can be proud that some of the earliest experimenters in the field of physics were members of the healing arts. To Gilbert, physician to Queen Elizabeth, goes the credit for the word "electric." Electrification is an electrical state known in two common forms: (1) electrostatics, that is, electrical substance at rest, and (2) electrodynamics, or electrical substances in motion. There are two kinds of electrical substances or charges; namely, positive and negative. The basic negative charge is the electron and the basic positive charge is the proton. The question "What is electricity" will probably not be answered in our lifetime, but when all is known about the composition of matter perhaps the question will be answered. The present concept is that all matter is made of electrically positive and negative particles, the negative charged electron and the positively charged proton. The proton

is apparently associated with the hydrogen atom and is about 1,850 times the mass of the electron. Electrification, therefore, is an accumulation of electrical substance which collects on a body or flows along a conductor. A condition of negative electrification involves an excess of electrons, whereas a condition of positive electrification involves a deficiency of electrons. There is no conclusive evidence that the proton moves; only the electron partakes of motion.

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Pohl, R. W.: Physical Principles of Electricity and Magnetism, London & Glasgow, Blackie & Son, Ltd.

ELECTROSTATICS

Since the dawn of history of physical sciences it has been known that amber rubbed with wool or cat's fur, or glass rubbed with silk will form a sort of magnet that will attract bits of paper and other like objects. When the glass is rubbed with silk, for example, the charge on the glass will be positive while that on the silk will be negative. When the glass and silk are separated, there is found between them an electrical state or field. A field of this kind is ordinarily of low capacitance [1] but may be either of high or low potential.[2] Devices that generate high potentials of static electricity are a variety of the machine developed by Wimshurst called influence or static machines.

At the present time static electricity is not used extensively in the treatment of disease because clinically it is of limited usefulness. Hence this branch of the subject will not be elaborated on any further in this article. Suffice it to say that such terms as brush discharge, frictional electricity, static wave current and franklinic electricity are terms pertaining to the use of static electricity in the practice of medicine.

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1. Capacitance (capacity) is that property of a system of conductors and dielectrics which permits the storage of electricity when potential differences exist between the conductors. A dielectric is a medium having the property that energy required to establish an electric field is recoverable, in whole, or in part as electric energy, as for example a vacuum, glass, oil or paper. The unit of capacitance is the farad.

2. Electrical potential at any point is measured by the work necessary to bring a unit positive charge from an infinite distance. Its unit is the volt.

ELECTRODYNAMICS

The study of electricity in motion is known as electrodynamics. Electricity is said to flow along a conductor when it is connected between points of high and low electrical potential. Some materials permit electricity to flow more readily than others. A material that facilitates the flow is called a good conductor. It has a low resistance. For example, copper wire is a good conductor, whereas a poor conductor restrains the flow; e. g., along moistened thread. Two points of unequal potential tend to equalize themselves if connected by a conductor unless there is some energy which continues to maintain the potential difference.[3] The two points connected with a low resistance conductor come to equal potential more rapidly than if they are connected with a conductor of high resistance. The potential difference is measured by the unit called the volt.[4] The quantity of current flowing per second is measured by the ampere [5] and the resistance to the flow by the ohm.[6] There is a definite relation among these three units; it is known as Ohm's law.[7] In general, all metals are good conductors (although some metals are better than others) and other materials poor conductors. Electricity will flow through certain aqueous solutions of salts and through gases.

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3. Potential difference between two points is 1 volt if a charge of 1 coulomb either requires or expends 1 joule of energy in moving from one point to the other. The coulomb is the unit for quantity of electricity.

4. Volt is the unit of electromotive force which is measured by the work done on each unit of charge as it passes through the source. A volt equals one hundred million abvolts. An abvolt in the centimeter-gram-second (c. g. s. absolute system) is the electromagnetic unit of potential difference between two points when 1 erg of work is required to transfer 1 abcoulomb of positive electricity from the point of lower potential to the point of higher potential. An abcoulomb is the c. g. s. unit for quantity of electricity. The erg is the c. g. s. unit of work. A volt is also the unit for electromotive force.

5. An ampere is equal to one tenth of an abampere. It is the unit of electric current. The abampere is defined by means of a law connecting the current in an electric circuit with the magnetic intensity at any point in its magnetic field. Its value is determined by means of an instrument which resembles a balance.

6. An ohm equals one billion abohms. An abohm is the resistance of a conductor when, with an unvarying current of 1 abampere flowing through it, the potential difference between the ends of the conductor is 1 abvolt.

7. Ohm's law states that the current in an electric circuit is directly proportional to the electromotive force in the circuit; e. g., the electromotive force in volts is equal to the current in amperes times the resistance in ohms.

DIRECT CURRENT

Current electricity is generated in two forms: direct current, which is a steady unidirectional flow, and alternating current, which changes its direction of flow periodically.

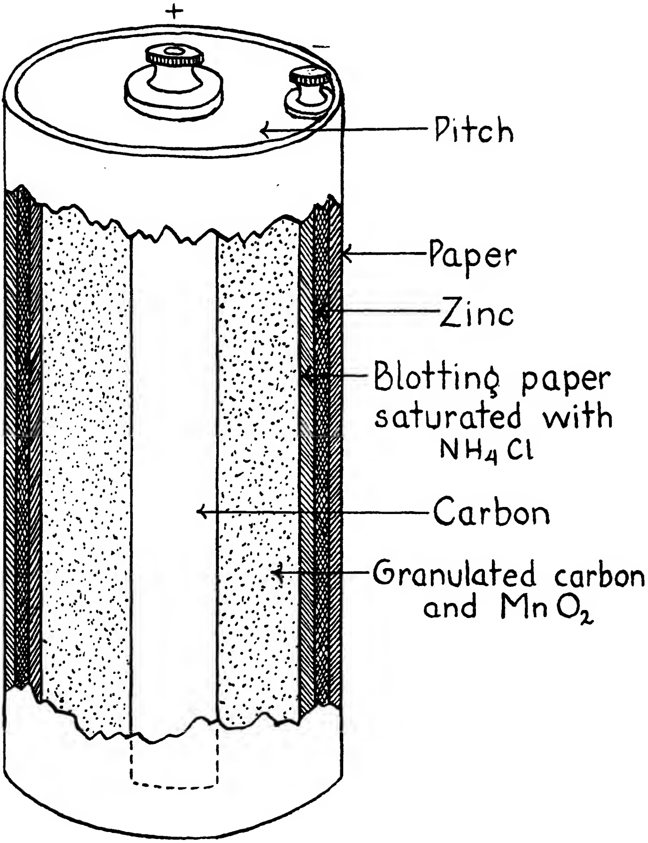

Fig. 1.—Dry cell. The common primary source of low voltage current. A battery consists of two or more cells.

Direct current is used in physical therapy for stimulating muscle and for ion transfer.[8] When used in the

8. Ion transfer is defined as the introduction of soluble salts into the tissues by means of direct current. It is sometimes called iontophoresis, common ion transfer, ionization, medical ionization, ionic medication or therapeutic ionization.

practice of medicine it is also called constant current, continuous current, galvanic current and galvanism. The simplest generator of steady direct current is the primary cell. Two or more cells connected in series, positive to negative, make a primary battery. Although there are several types, the dry cell (fig. 1) (a variation of the Leclanche cell) is the most common and is used almost exclusively at the present time as a primary source of direct current. Briefly, it consists of a

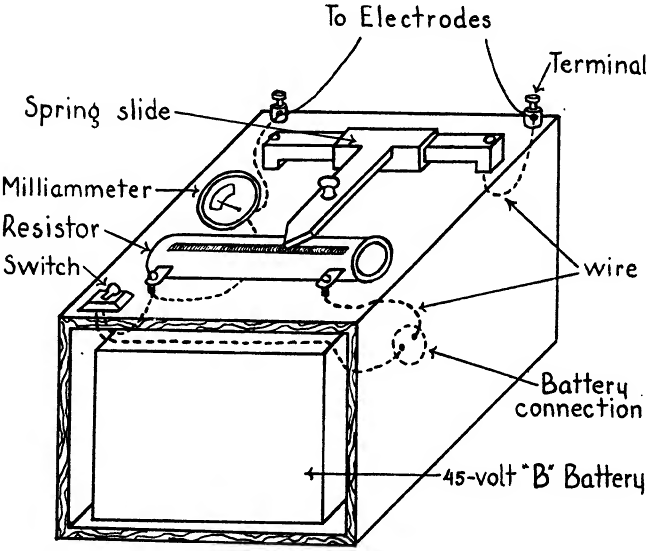

Fig. 2.—Simple galvanic generator. It consists of a 45 volt B battery, a milliammeter and a resistor. This is a convenient method for generating and controlling galvanic current.

zinc cup in which there is packed a moist acid paste and a carbon rod in the center; the top of the cup is sealed by pitch. The action of the acid on the zinc creates a potential difference between the carbon and the zinc terminals, amounting to approximately 1½ volts. Thirty of these cells (small flashlight cells) connected in series form the well known 45 volt B battery, which is frequently used for energizing therapeutic apparatus.

A simple form of instrument for stimulating a muscle or a nerve or for use in ion transfer is shown in figure 2.

This consists of a resistor, a coil of wire of 2,000 ohms resistance, a battery, a milliammeter and a slide. Physicists call an instrument with this hook-up [9] a potentiometer. The entire voltage of the battery is impressed on the resistor and hence the fall in potential is directly proportional to the number of turns of wire. For example, if a potential of 45 volts is impressed on the

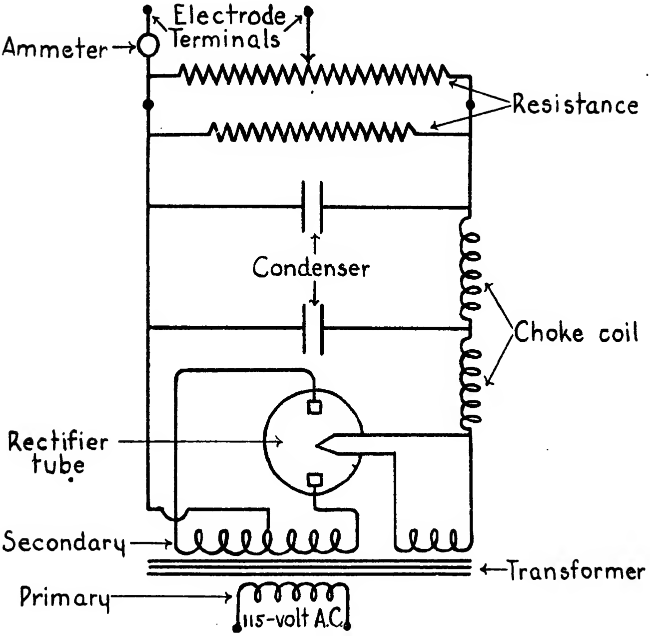

Fig. 3.—Schematic diagram of an instrument for generating galvanic current. It consists essentially of a rectifier and a potentiometer.

resistance, at the half-way mark, theoretically between the middle and common end, the voltage will be 22½ volts. A movable slide enables the operator to select any potential desired between 45 and zero volts. At the one-quarter point the potential is 11¼ volts. Specifications may be obtained from the Council on Physical Medicine for making a homemade galvanic generator somewhat like the one described.

9. Hook-up is a convenient and common term used when speaking of the arrangement and wiring of a radio or other electrical apparatus.

Most commercial electrogalvanic instruments which generate direct current are a combination of the potentiometer and a rectifier. The rectifier is an electrical device that transforms alternating current into direct current. Rectifiers may be of the vacuum tube, mechanical, electronic or electrolytic type. The most common is the one utilizing thermionic tubes.[10] Figure 3 is a diagram of the circuit which may be used with the vacuum tube type of rectifier. The electric current from this device when used for muscle stimulation is connected to an electrode equipped with a button switch. The operator interrupts the current according to his wishes. For ion transfer one terminal is connected to the dispersive or large electrode while the other is connected to the active or smaller electrode. These instruments are also employed for removal of superfluous hair. More information is to be found on this subject in textbooks.

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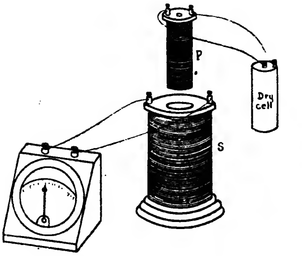
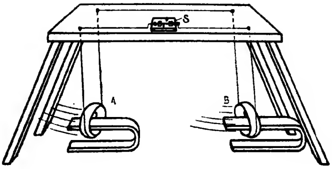
ALTERNATING CURRENT

An electrical current whose direction changes periodically is known as an alternating current. It is familiar to all, since most of the power distributed for household and industrial use is 60 cycle alternating current. This means that the current changes its direction 120 times a second. In one-half of the cycle the current is in a positive direction and the other half in the negative direction. Alternating currents used in electrotherapy range in frequency from a few cycles per second for muscle stimulation to millions of cycles per second in the case of short wave diathermy. As the frequency increases the physical characteristics of the current and also the physiologic effects on tissues

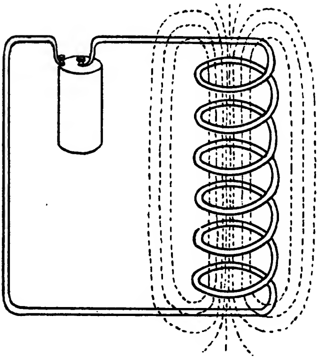
10. Thermionic tube is a vacuum tube in which one of the electrodes is heated for the purpose of causing electron or ion emission from that electrode.



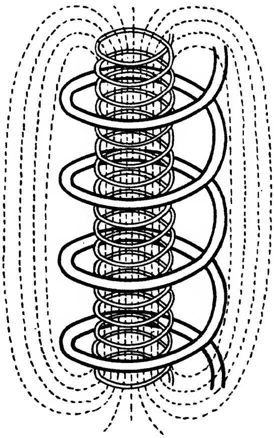
Induction. Primary coil P is connected to a dry cell and secondary coil S is connected to a sensitive meter. By moving the coil P in or out of the other coil S, a current is induced and its presence recorded on the meter, but only when the coil P is moved. With the coil P, inserted in the coil S and stationary, a voltage is induced in S when the circuit in P is opened and closed. A current flows in S only if and when the circuit is complete.



Simple Demonstration of Electromagnetic Induction. Two coils each with many turns of wire (A and B) are suspended from a frame by conductors and are free to swing back and forth in the poles of the permanent magnet as shown. There is a continuous metallic electric circuit between the coils A and B except when switch S is open. If coil A is set in motion with the switch open it will swing freely while coil B will remain stationary. Closing the switch thereby completing the circuit, the electrical current established will energize the coil A. Hence, coil A functions like a dynamo and B as a motor. Turning one of the magnets upside down, the motion of B with respect to A will be changed.



Electricity passing through the wire of coil generates magnetic field. Lines of force surround the coil and thread through its center. An iron core greatly intensifies the magnetism.



Induction. The coil carrying a varying electric current which excites a varying magnetic field will generate in the second coil voltage by mutual induction resulting in a current when circuit is complete.

change. For example, low frequency alternating currents create the sensation of electrical shock and high frequency currents the sensation of warmth.

LOW FREQUENCY ALTERNATING CURRENT

(5 to 100,000 cycles per second)

Alternating currents in this frequency range are called tetanizing currents but are sometimes referred to as faradic or induced currents, and the procedure is called

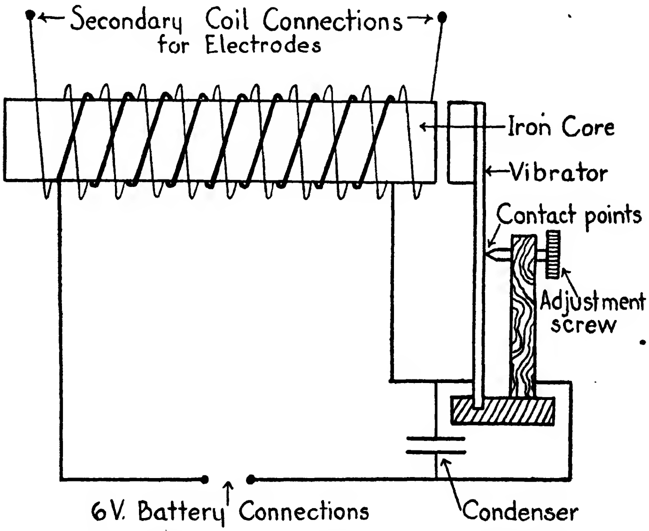


Fig. 4.—Schematic diagram of induction coil. An instrument of this type may be used for generating tetanizing current to stimulate nerves or muscles.

faradism or faradization. These currents are used almost exclusively for stimulating muscles and nerves. They can be generated by two means: (1) the Ruhmkorff coil, more often called an induction coil, and (2) a small motor generator set (a commercial product) operated by ordinary wall plug electric power. The induction coil is the simplest type of generator of tetanizing currents. It consists of an iron core around which are wound two coils, the primary and the secondary. There is an interrupter which makes and breaks the primary circuit. Figure 4 is a schematic diagram

of an induction coil which may be used for generating tetanizing current. Electrical energy from the battery flows through a circuit consisting of a primary coil and the interrupter. When the switch is closed in the primary circuit the iron core becomes magnetized and attracts the iron disk on the vibrator of the interrupter, thus breaking the circuit at the contact points. The weight of the iron disk and the stiffness of the spring govern the frequency of the alternating current generated. When the current is building up in the primary coil it creates a magnetic field in the primary coil and the iron core. As a result of the magnetic induction,

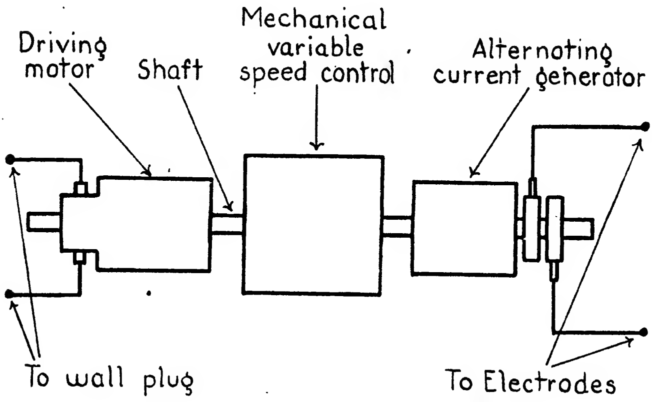


Fig. 5.—Schematic diagram of a wall-plug type tetanizing current generator. It consists essentially of a small electric motor driving through a mechanical variable speed control, a small alternating current generator.

a voltage is generated in the secondary coil, causing a flow of current. When the interrupter breaks or opens the circuit this magnetism or magnetic field collapses and generates a reverse voltage in the secondary coil, and the current flows in the opposite direction. The current generated in the secondary coil is an alternating current, whereas the current in the primary coil is an interrupted direct current. The resulting alternating current is not as smooth as would meet the exact requirements of a so-called sine curve. The voltage of the alternating current generated may be regulated by moving the secondary coil in or out of the primary coil or by moving the iron core in or out. The capaci-

tor[11] connected across the interrupter points greatly increases the efficiency of the coil, making use of the self inductance[12] in the primary coil. Specifications may be obtained from the Council giving directions for making a homemade tetanizing coil, in which an ordinary buzzer is employed for the interrupter.

Commercial tetanizing (faradic) current generators are usually but not always combined in a cabinet with galvanic generators. Figure 5 is a schematic diagram of one kind of circuit. This hook-up consists of a small constant speed motor which is mechanically connected through a variable speed control to a small alternating current generator. The motor obtains its power from the ordinary 60 cycle 115 volt power supply, and the output from the small alternating current generator is applied to the electrodes sometimes through a system of special interrupters and automatic switches which changes the wave form of the therapeutic current. Their construction is too varied and complex to discuss here. The following references will provide detailed information.

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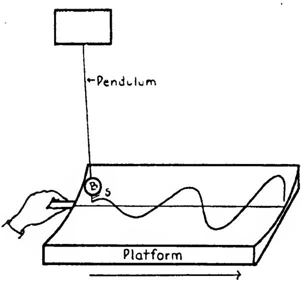
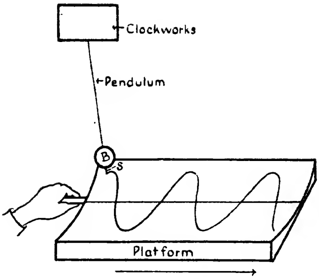
ALTERNATING CURRENT (HIGH FREQUENCY)
(100 to 10,000 kilocycles)
(corresponding wavelengths 3,000 to 30 meters)

An alternating current having a frequency of more than 100,000 cycles[13] per second is alternating or oscillating so rapidly that no sensation of electrical shock is felt when applied to the living tissues, but if the current is sufficiently intense there will be a feeling of warmth. In fact, if the high frequency oscillating current is concentrated at a very small point, for example,

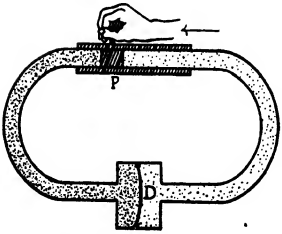
11. A capacitor, formerly called a condenser, permits storage of electricity.
12. Self inductance is the property of an electric circuit which determines, for a given rate of change of current in the circuit, the electromotive force induced in the same circuit.
13. A cycle is the complete series of values of a periodic quantity which occur during a period.



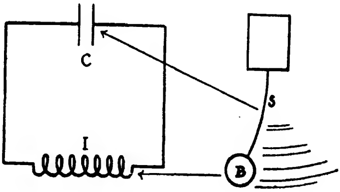
Damped Wave Motion. Assume a pendulum with bob B and stylus S and movable platform, its uniform motion in direction of arrow. Set pendulum swinging and "let the old cat die." Trace of stylus will be a curve of damped wave motion.



Undamped Wave Motion. Assume a pendulum with bob B and stylus S and a platform, its uniform motion in the direction of the arrow. The clockworks maintain constant amplitude of the pendulum. The trace of the stylus will be undamped wave motion.



Analogy of a Capacitor. Assume tube and chamber filled with water. The rubber diaphragm D separates liquid on right side from that on the left. Pushing piston in the direction of arrow will extend rubber diaphragm as shown. Releasing the hand, the piston will return to neutral position. Pulling piston rubber diaphragm will extend itself in the opposite direction. Oscillating electrical energy may be transferred through a Capacitor even though it has no metallic contact.



Analogy of an Oscillating Circuit. An inductor I and a capacitor C when connected as shown are analogous to the mass of the bob B and the elasticity of the spring S. If the bob B is made heavier the pendulum will oscillate slower. Analogously if the inductance of the coil is made greater the oscillating current in the circuit will have a lower frequency.

the wire point of an electrical cutting knife, then destruction of tissues may take place. Oscillating currents of the frequency mentioned are sometimes called diathermy currents (medical and surgical), d'Arsonval current, Tesla current and Oudin current. The modern term for oscillating currents in this category is long wave diathermy. Although these currents have been used for medical diathermy, at the present time they are employed most widely for surgical diathermy, chiefly for fulguration, electrocoagulation and electrodesiccation. For generating these currents the spark gap type of generator is employed most widely, although vacuum tubes have been used.

By pure mathematical deduction Maxwell showed that electromagnetic waves behaved somewhat like light. Credit goes to Hertz, who devised experiments proving Maxwell's theory. High frequency oscillating currents are sometimes called Hertzian waves.

Tesla devised an electrical circuit that generates high frequency currents for diathermy application. His hook-up consists of a step-up transformer, T (fig. 6), having a ratio of 100:1 or more and connected to an oscillatory circuit indicated by the curved arrow. This circuit contains a capacitor, *C*, a spark gap, *G*, and an inductor, *P* of a dozen turns or so, which is also the primary of the second transformer *HT*. This high frequency transformer, *HT*, is constructed without iron, whereas the first transformer, *T*, is of the conventional type having an iron magnetic pathway. When an alternating current is impressed on the primary of the transformer *T* a spark discharges across the spark gap, *G*. The action within this circuit is as follows: An electric current of high voltage is induced in the secondary winding of the transformer *T* having the same frequency as that in the primary, in this instance 60 cycles per second. The potential builds up in the positive half cycle, charging the capacitor *C*. When the voltage is high enough, a spark passes between the points of the gap *G*. The gap is now ionized and the resistance lowered for a fraction of a second. Momentary lowering of resistance in the oscillating circuit permits the capacitor to discharge completely and indeed overextends itself and builds up a negative potential but less in strength. Now the negative potential discharges and the capacitor builds up positively.

Thus an oscillating current of extremely high frequency is generated in the circuit and continues to oscillate until equilibrium in the capacitor is reached. This sequence of events is again repeated in the negative half cycle of the 60 cycle alternating current. The

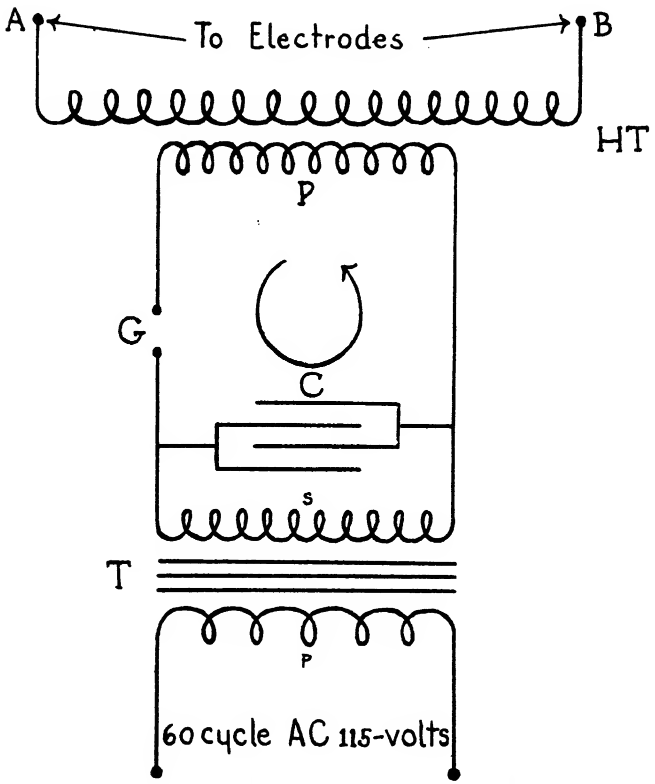


Fig. 6.—Schematic diagram of Tesla coil. It consists of a transformer T with primary p and secondary s windings, a high tension transformer HT, capacitor C and spark gap G. Curved arrow indicates the high frequency oscillating circuit.

curves in figure 7 show graphically what takes place electrically in the Tesla hook-up. The trace of the current is a damped oscillatory motion. An analogy in slow motion would be the releasing of a pendulum and allowing it to beat back and forth until it comes to rest. The frequency of the oscillating current depends

on the values of the capacitance in the capacitor, *C*, and of the inductance in the coil *P*. The resistance of the circuit also plays an important part. Changing one of the three, inductance, capacitance or resistance, will alter the frequency. It is possible to generate in the secondary winding of the transformer *HT* a damped high frequency current which oscillates at a rate of as much as 500 kilocycles or more per second.

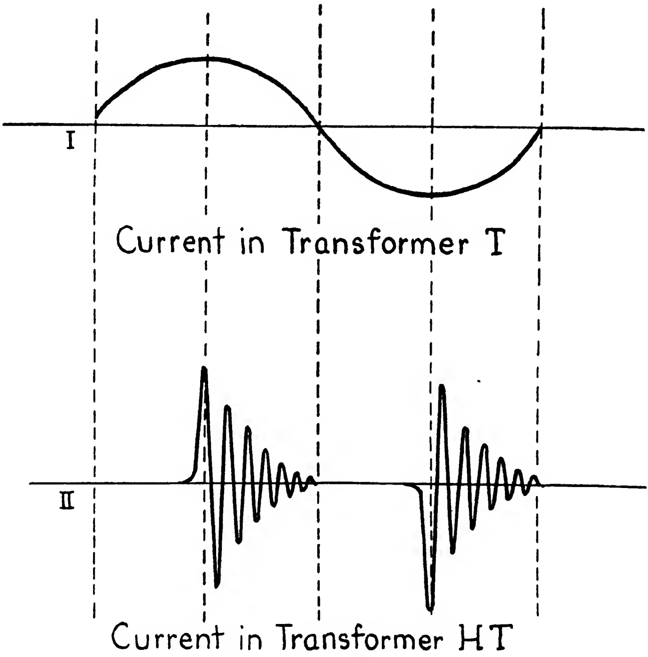


Fig. 7.—Sine curve I represents one cycle of alternating current in the transformer T (fig. 6). Curve II represents the high frequency current in the high tension transformer HT.

Before the advent of short wave diathermy employing vacuum tubes the spark gap was used almost exclusively for generating medical diathermy current. Contact electrodes are connected to points *A* and *B* of the transformer *HT*. The frequency being so great there is no neuromuscular response and the high frequency current passes through the tissues and generates heat within them.

ALTERNATING CURRENT

(10,000 kilocycles to 100,000 kilocycles or higher)

(wave length 30 to 3 meters or shorter)

Alternating current of this frequency, as applied to medicine, is called short wave diathermy. The principle wavelengths employed are from approximately 25 to 6 meters. Two principles. "electromagnetic field" and "electric field," are employed in applying the oscillating current to the body tissues. The "electric field" utilizes pads, cuffs and air spaced electrodes. The "electromagnetic field" employs coils and drum electrodes. Oscillating current in this range may be used for surgical diathermy, although the longer wavelengths—100 to 500 meters—seem preferable to many surgeons. These oscillating currents are generated for the most part by means of vacuum tubes. The wave form is undamped, in contradistinction to the oscillating currents generated by spark gap apparatus, which are damped.

Figure 8 is a diagram of a simple oscillating circuit. The coil and capacitor make up the main oscillating circuit, *A*, *B*, *C*, sometimes called the tank circuit. The vacuum tube elements are indicated by the conventional notations; e. g., *F* for filament, *G* for grid and *P* for plate. For convenience of explanation the current supply for both the plate circuit and for the filament come from A and B batteries. In an actual diathermy apparatus these batteries may be substituted for a rectifier, which is not described in this chapter. (A schematic diagram of a rectifier is shown in figure 3.) Employing the sine curve shown at the top of figure 8 as an explanatory aid, the operation of this oscillating circuit will be described. The sine curve 1, 2, 3, 4 and 5 represents the trace of the oscillating current generated by this circuit at the treatment electrodes. For example, the high frequency current may be 10,000 kilocycles per second or corresponding to 30 meter wavelength. It also represents one cycle of the current oscillating in the fundamental circuit *A*, *B*, *C*. Positive charges in the capacitor *C* first appear on the A side, then during the last half of the cycle appear on the B side, That portion of the curve above the center line *xy* represents positive electricity and that below negative. In other words, for an oscillating current of 10,000 kilo-

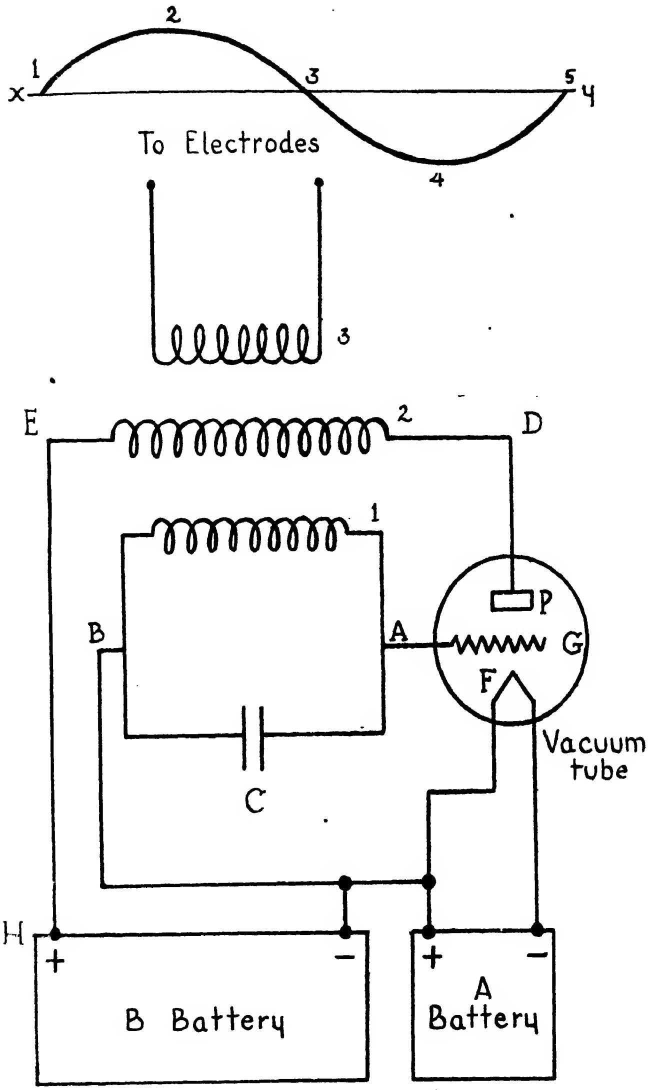
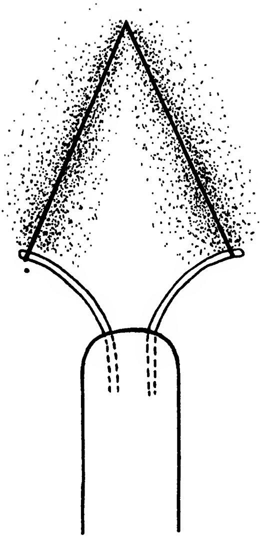
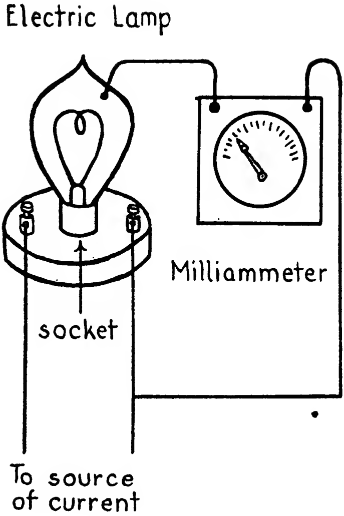


Fig. 8.—Schematic diagram of one type of oscillating circuit. In actual practice a rectifier replaces the A and B batteries. Batteries are used here for convenience of explanation. The curve represents one cycle of the high frequency current.

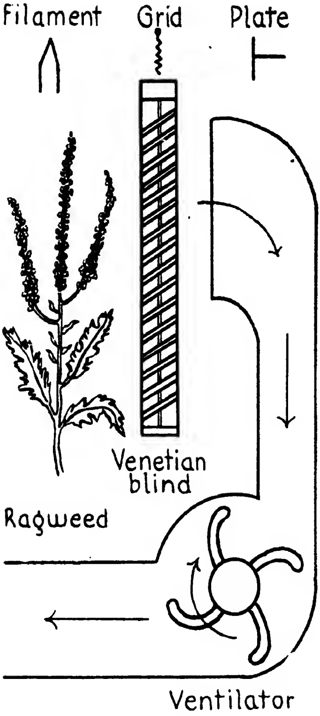
cycles (30 meters) the current in the circuit *A, B, C* will flow in the positive direction for five millionths of a second and then flow in the negative direction for five millionths of a second. Let us consider the small part of the current represented by the segment on the curve from 1 to 2. This is a rising positive current and its characteristics from instant to instant in the tank circuit *A, B, C* is represented by the trace of the curve. Assume the charge at the point *A* connected to grid *G* of the vacuum tube is a positive rising current. Hence the positive charge on the grid accelerates the flow of electrons and also increases the plate current in the circuit *P, D, E, H* energized by the B battery. The rising current flowing through coil 2 establishes a magnetic field whose lines of magnetic force cut coils 1 (and incidentally coil 3), thus making the current in coil 1 flow in such a direction as to make the charge on the A side more and more positive. The rising current will continue to be positive until the potential at *A* reaches and equals the voltage of the plate current, that is, the voltage of the A battery. The voltages of the two coils being equal, there ceases to be a rising current in coil 2 and the magnetic field becomes weaker and weaker. The capacitor *C*, being fully charged, positively, attempts to equalize itself and then discharges. The current in the oscillating circuit *A, B, C* now flows in the opposite direction. The potential at *A* falls. This is represented on the sine curve from 2 to 3. But the current in the oscillator circuit, performing much like a pendulum, continues to discharge and passes through the zero point and becomes negative, represented on the sine curve from 3 to 4. Point *A* and the grid are now negative. The current flow in circuit *P, D, E, H* has been stopped by the valve action in the space between the plate *P* and the filament *F* of the vacuum tube. The oscillating current continues to increase in the negative direction until approximately the same potential is reached negatively as was reached positively. Now the *B* side of the capacitor begins to discharge, which causes a change in the charge at point *A*. When the potential reaches the neutral point 6 on the curve, the grid builds up positively once more. The vacuum tube, acting like a valve, permits electrical energy from the B battery to flow once more in the plate circuit *P, D, E* and *H*.



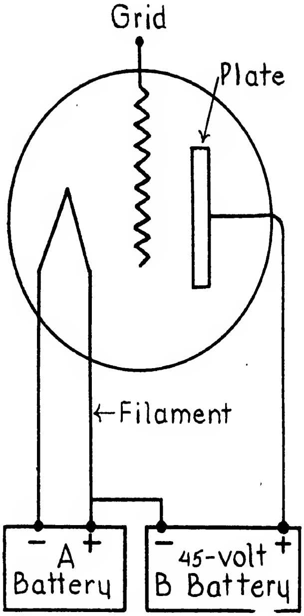
Filament of a thermionic tube. A hot body such as the filament in the vacuum tube emits negatively charged particles called electrons.



Edison Effect. Edison noticed that the inside surface of the glass envelope of a carbon filament lamp after burning many hours became discolored. Inserting an electrode in the top of the glass envelope as shown, Edison found that current flowed when the electrode was positive but did not flow when it was negative.



An analogy of a vacuum tube. The ragweed is analogous to the filament, the pollen to the electrons, venetian blind to the grid, the ventilator to the plate, and the fan to the B battery. The pollen is drawn to the ventilator when the venetian blind is open (positively charged grid) but pollen is stopped when blind is closed (negatively charged grid). An analogy will frequently help one to understand an electrical principle, but will break down if applied too literally.



Schematic diagram of the vacuum tube and circuit. The filament is heated by current from the A battery, thus establishing electron emission. The electrons being negatively charged are attracted to the positively charged plate. The grid controls the flow of electrons. If the grid is positive the electron flow is accelerated but if the grid is negative the flow is inhibited.

The cycle is now complete and the sequence of events just explained repeats itself. Coils 1, 2 and 3 are magnetically coupled and the oscillating current induced in coil 3 becomes the diathermy current which is used for treatment. The oscillating current in coil 3 is of the same frequency as that in the tank circuit *A*, *B*, *C*. Not only does the energy drawn from the batteries operate the unit but a part of the energy is converted into high frequency oscillating current to be delivered to the rubber or glass insulated electrodes and utilized for heating tissues.

The simple oscillating circuit herein described will work, but it is not a practical hook-up for diathermy design. Other circuits, such as the Hartley and Coplits and tuned-plate, tuned-grid circuits, appear to give more satisfactory results but are much more difficult to explain.

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CONCLUSION

The foregoing is a brief discussion of the electrical phenomena which a physician using physical therapy equipment is likely to encounter in his everyday practice. The references given under each caption will serve as a directory to books in which more detailed information may be obtained regarding the physical subjects discussed.

MEDICAL DIATHERMY

COUNCIL ARTICLE

Medical diathermy is the therapeutic use of heat generated in the body tissues by a high frequency current which has insufficient local intensity to produce temperatures high enough to destroy the tissues or impair their vitality. Such currents are applied locally by three methods: (1) long wave diathermy, contact metal electrodes being used, (2) short wave diathermy with an electric field, air-spaced or insulated electrodes being used, and (3) short wave diathermy with an electromagnetic field method, a cable being used.

In long wave diathermy the frequency of oscillation is usually from one-half million to three million cycles a second. In short wave diathermy the frequency of oscillations may be from ten million to 100 million cycles a second.

PHYSIOLOGIC EFFECTS OF LOCAL MEDICAL DIATHERMY

The effects of electric current when applied to tissues of the body may be thermal, chemical or mechanical, depending on the physical characteristics of the current. The fundamental reason for using high frequency currents for heating is that the body heat may be raised without injury or electrical stimulation.

With regard to short wave diathermy, there has arisen considerable controversy as to whether it produces specific effects other than those of heat. In the light of present observations, the consensus seems to be that no definite physiologic effects other than those attributable to heat have been substantiated. The physiologic effects of heat have been considered by Pemberton [1] and will not be discussed here.

SHORT WAVE DIATHERMY VS. LONG WAVE DIATHERMY

The consensus seems to be that there is no great difference in the effects produced by short wave diathermy and long wave diathermy except that the former apparently produces deeper, more uniform heating and is more readily applied.

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1. Pemberton, Ralph: Physiologic Effects of Heat, Handbook of Physical Therapy, 1939.

DOSAGE

The regulation of doses in medical diathermy is empirical. In short wave diathermy the only recognized method of measuring doses is the comfortable heat sensation of the patient's skin. The milliammeter on the high frequency apparatus does not measure the electrical energy passing through the patient. In high frequency apparatus the milliammeter indicates the amount of current passing through it but does not measure the electrical energy passing through the patient. The patient's tolerance is the most important guide for the final dose to be used. If it is suspected that the sensibility to heat may be deficient in the skin over which the electrodes are placed, it is advisable to test the skin with hot water in a test tube, using the operator's skin sensation as a control.

It is to be emphasized that in short wave diathermy there should be no clothing between the electrode and the skin. A burn received from a treatment by short wave diathermy when the clothes have not been removed might readily provoke a medicolegal situation. After the treatment it is important to inspect the skin of the part treated.

The regulation of dosage with short wave diathermy is an even more empirical procedure than with long wave diathermy. The milliammeter is connected to the oscillatory circuit of the apparatus and serves chiefly as an indicator that electrical energy is passing. It will also indicate that in a certain position of the controls, when the patient's circuit is tuned to the oscillator circuit, there is a maximum flow of energy in the treatment field.

CONTRAINDICATIONS

It is important to keep the contraindications for diathermy in mind. The local application of high frequency currents is contraindicated in the case of certain acute inflammatory processes, such as acute nondraining cellulitis and acute infectious arthritis, or any condition in which there is a tendency to hemorrhage, such as a gastric ulcer; over areas in which the appreciation of heat has been impaired or lost, as in the case of certain peripheral nerve injuries; through the abdomen, pelvis or lower part of the back during pregnancy; during menstruation or thirty-six hours before or after menstruation, and over areas where a malignant growth is suspected.

INDICATIONS

Contusions.—The early application of cold by compresses or ice bag will reduce ecchymosis, swelling, pain, tenderness and limitation of motion. After the first twenty-four hours, infra-red radiation and medical diathermy may be applied to increase activity of the circulation.

Muscle Strains.—These are treated like contusions with regard to the application of cold and heat. For muscle strains, diathermy must be applied for only a short time and at a low intensity for the first treatment, as it may cause an increase in the swelling.

Myositis Ossificans.—With muscle injuries there is always the possibility of the development of myositis ossificans, which tends to progress unless the affected area is properly treated. The treatment consists primarily in rest and increase of local circulation by various means, especially diathermy.

Sprains and Dislocations.—There are various degrees of sprains, and treatment varies in direct proportion to the damage done to the soft tissues. Immediate walking may be advised in cases of slight sprain of the ankle, while rest in bed may be indicated in cases of severe sprain.

A mild sprain of the ankle can be treated satisfactorily by strapping to prevent lateral motion but not plantar and dorsal flexion. The efficacy of this method depends on the efficiency of the strapping. It is thought that plantar and dorsal flexion have a direct effect in promoting return of circulation and prevention of adhesions.

In the treatment of some sprains and dislocations, fixation by a removable plaster splint and the daily application of heat and massage may be preferred. In sprains or dislocations, ligaments are torn and muscles, blood vessels, nerves, tendons and the synovial membranes of the joint are injured; there are hemorrhage from the torn vessels, swelling and muscle spasm. Inflammatory action is noted with heightened local metabolism and elevation of temperature. For immediate treatment, therefore, local applications of cold with rest, proper compression, bandaging and elevation are indicated. After the first twenty-four to forty-eight hours, there are local edema and decreased local metabolism. Then the treatment should consist in removal of

the splint and bandage followed by the application of external heat or diathermy, and this is usually succeeded by massage and exercise to produce a free flow of blood through the part. One must not forget, however, that other methods of applying external heat are available, such as those described in other chapters of the Handbook of Physical Medicine concerning heat. Among other important measures following the heating of these parts is the stimulation of circulation by massage and exercise.

Bursitis.—The first attack of bursitis can usually be relieved by physical therapy in about two weeks. The part should be placed at rest. For acute bursitis, infrared radiation from a luminous source is given for thirty minutes at least twice daily and short wave diathermy is applied for twenty minutes once daily. As the pain diminishes, careful massage and relaxed motion should be employed; later, active exercise is started. Acute subacromial, radiohumeral, olecranon and prepatellar bursitis are treated in this manner. In a few cases, diathermy may aggravate the pain. In these cases it may be necessary to put the patient to bed and apply continuous moist heat.

For chronic subacromial bursitis, conservative measures, such as rest, infra-red irradiation, short wave diathermy, massage and exercise should be tried before operation is considered. In some cases of chronic involvement with severe pain the shoulder should be immobilized in an airplane splint. In this form of bursitis, calcified deposits may form without any apparent cause, are often fragmented and may disappear spontaneously. It is believed that diathermy may aid in the absorption of such deposits. When conservative measures fail, operative removal of the bursa and its calcified deposit is advised.

Tenosynovitis.—Traumatic tenosynovitis most commonly affects the tendons of the wrist, the achilles tendon and the long head of the biceps. The treatment is to immobilize the joints whose motion causes pain in the tendons. The splint is removed and short wave diathermy is applied for twenty minutes once daily, followed by radiant heat once or twice daily for twenty minute periods. It may be advisable to use motion in a whirlpool bath to prevent adhesions.

Rheumatic, gouty and gonorrheal tenosynovitis are treated in the same manner as the traumatic form.

Pyogenic tenosynovitis is a surgical problem and diathermy is not used in its treatment.

Chronic Arthritis.—This is not a disease of certain joints but rather a systemic illness, in which there may be disturbances of the circulation, general metabolism, gastrointestinal tract and nervous system. The syndrome of chronic arthritis includes the nerve, muscle and joint diseases called neuritis, myositis, fascitis and arthritis, according to the part affected. Local and general applications of heat have perhaps their most extensive varied usage in the treatment of chronic arthritis. In chronic arthritis the circulation in the more narrow vessels, especially at the periphery, is usually diminished. The involved areas may be cold and clammy, but they may also present rubor, dolor and color. In any event, local heat may prove of great value, as may systemic applications, because of the alteration and improvement in the circulation brought about. Great care should be exercised in the application of heat in cases of hypertrophic arthritis, since heat may constitute a form of trauma which aggravates the conditions already present. When indicated, however, local application of heat should be made from two to four times a day in the patient's room to produce an adequate increase in circulation, and, if medical diathermy is used, it may be supplemented with the former treatment. When medical diathermy is used for chronic arthritis it should be used for a short period with low intensity for the first few doses, because sometimes it causes an aggravation of the local symptoms. Clinical benefit, however, has been observed so often from diathermy that one should always give it a trial.

Myositis and Myofascitis.—These conditions are inflammations of the muscles characterized by pain on motion, spasm and tenderness on pressure. When the inflammation involves the lumbar muscles, it is known as lumbago; the intercostal spaces, pleurodynia, and the neck muscles, torticollis. In the local treatment of acute forms, rest and the application of heat are recommended. This heat may be applied by hot compresses, continuous moist heat, infra-red radiation from a luminous source or medical diathermy.

Fibrositis.—This has been defined as a swelling and proliferation of the white fibrous tissue anywhere in the body in response to injury or very toxic infection, with

a secondary effect of pressure on arterioles and nerve filaments. Many American clinicians have been loath to recognize fibrositis because its morphologic lesions are ill defined and its symptoms subjective. Those who do recognize it by its nodules in the muscles classify most forms of muscular rheumatism as fibrositis and treat the condition with deep massage. Heat, massage and exercise are used as adjuncts in the treatment, and diathermy may be used as one of the methods of giving heat.

Fractures.—The principles of fracture treatment are restoration of anatomic form, maintenance of alinement and fixation of the fracture during the period of union, and maintenance and development of function. For a more complete discussion, see "Physical Therapy in the Treatment of Fractures," by Dickson.[1] Heat, massage and mobilization are important physical therapy measures, the object of which is to increase the activity of the circulation, to prevent adhesions in muscles and joints, to prevent muscular atrophy and later to increase muscle strength. The heat, of which one method of production is medical diathermy, is used mainly as an adjunct to massage and exercise.

Genito-Urinary Conditions.—Medical diathermy is used by a few clinicians as one of the methods of applying heat for the treatment of epididymitis and prostatitis.

Pelvic Infections.—Some gynecologists use medical diathermy as one of the methods of applying heat in cases of pelvic infection, although most gynecologists believe that a low degree of heat usually suffices.

Respiratory Diseases.—The chest compress is used by some clinicians to apply heat in the treatment of bronchitis. If the patient is in the hospital, it is believed that medical diathermy is more effective and easier to apply. With bronchitis, this method relieves the pain and soreness in the chest, reduces the viscosity of the secretions and thus makes expectoration easier; it also relieves the coughing.

It has been observed that, in the management of pneumonia, medical diathermy does seem to be of definite benefit in reducing the severity of thoracic pain.

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1. Dickson, Frank D.: Physical Therapy in the Treatment of Fractures, Handbook of Physical Medicine, p. 303. First edition 1945. A. M. A., Chicago.

This symptomatic relief is important. The main factors concerned in the production of anoxemia are the passage of blood through the unaerated portion of the lung and shallow breathing. The shallow breathing may be due to pleuritic pain restricting the respiratory excursions. The relief of this pain by diathermy increases the respiratory excursions and this may be the explanation for the decrease in cyanosis that is usually noticed. There is no evidence that medical diathermy has a specific action on the pneumonic process.

Gastrointestinal Diseases.—For such conditions as acute enteritis, spastic colitis and simple catarrhal jaundice, abdominal warmth is suggested as an aid in treatment. An electric heating pad or a hot water bag kept on the abdomen for hours at a time is useful therapeutically. Infra-red irradiation is a convenient way of applying heat; diathermy, if mild and properly applied, is also of benefit.

Inflammation of the Peripheral Nerves.—With the various forms of neuritis, radiculitis and neuralgia, applications of heat may allay the inflammation and the pain. For deep penetration of heat into the tissues, medical diathermy may be used as a method of applying heat as an adjunct in general treatment. In the case of acute neuritis or acute radiculitis, it is believed that the first two treatments should be given at half the patient's tolerance for about ten minutes to see whether there is any aggravation of the symptoms.

Acute and Chronic Sinusitis.—Infra-red irradiation and medical diathermy are useful adjuncts to other treatment after adequate drainage has been established. Medical diathermy is of value as an aid in the relief of pain; the frontal and maxillary sinuses are the ones most suitable for treatment.

Eye Diseases.—The indications for medical diathermy are by no means well established. It is believed that this treatment may be used to relieve pain from chronic keratitis, neuralgia, herpes zoster and iritis.

Suppurative Processes.—Short wave diathermy has been advocated in the treatment of suppurative lesions with external drainage and doubtless will be of aid in this treatment. However, sufficient comparative study is not available to determine whether short wave diathermy is more effective than the simpler forms of heating.

SUMMARY AND CONCLUSIONS

While there appears to be no great difference between the effects produced by long wave and short wave diathermy, short wave diathermy seems to produce deeper, more uniform heating and is more readily applied, although the control of dosage is more difficult than with long wave diathermy. Nevertheless, burns are less likely to be produced in short wave diathermy.

So far as competent investigators have been able to determine, there is no demonstrable selective thermal action in the living body. The Council has accepted certain short wave apparatus, which are listed in this booklet.. Physicians are urged to read this booklet before purchasing an apparatus. The Council requires certain definite tests for deep heating before accepting an apparatus, and its survey of the machine gives the results of these tests as well as the efficiency and accepted technics for use of the machine.

Clinical observations, however, have not indicated that the penetration of heat induced by short wave diathermy presents advantages not obtained by long wave diathermy. In the light of present observations, no specific physiologic effects other than those attributable to heating have been substantiated.

The consensus (particularly of those who have performed careful experiments) would seem to be that the effect of various wavelengths between 3 and 30 meters is approximately the same. There are apparently no specific bactericidal effects other than those attributable to heat, either in vitro or in vivo. There is no reason to believe that treatments of five minutes or less have any marked action other than a psychic one.

The chief advantages of short wave diathermy over long wave diathermy are its ease of application and the lessened danger of burns.

ELECTROLYSIS

A DISCUSSION OF EQUIPMENT, METHOD OF OPERATION, INDICATIONS, CONTRAINDICATIONS, AND WARNINGS CONCERNING ITS USE

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NEW YORK

This article is prepared especially for those who are not familiar with the technic of application of electrolysis, the equipment and its uses.

Electrolysis is far from being a safe procedure in unskilled hands. Carelessness and ignorance when applied to electrolysis may cause injuries to the skin which are objectionable, disfiguring, painful and even, at times, dangerous.

Electrolysis, incorrectly termed "surgical ionization," involves the destruction or decomposition of tissues with the negative pole of a galvanic current. In chemistry the term electrolysis designates the decomposition of a chemical compound—that is, the separation of an electrolyte in solution into its constituent parts by a galvanic or direct current. Electrophoresis, incorrectly termed "medical ionization," includes iontophoresis. When medicaments are applied to the body either the positive or the negative pole may be the active electrode, depending on the drug used. The remaining indifferent electrode is used on some other portion of the body. Electrophoresis may be utilized without the necessity of employing any drugs. MacKee [1] states that it is averred that with the negative pole there is vasodilatation and a softening effect on new formed tissue (scars), while with the positive pole there is vasoconstriction and hardening.

Electrolysis is very useful for the treatment of certain conditions. In fact it is the only method for permanent and safe removal of unwanted hairs on various parts of the body. It is also the method of choice in treating

1. MacKee, G. M.: Handbook of Physical Therapy, Chicago, American Medical Association, 1937, p. 386.

many other dermatologic conditions. Michel[2] in 1875 successfully cured a case of trichiasis by the use of electrolysis.

APPARATUS

Any apparatus used for medical purposes has both advantages and disadvantages. It is well before using any new instrument to be especially familiar with the dangers. The apparatus employed by most American dermatologists consists of a 22½ volt dry battery hooked up to a small rheostat, a milliammeter and two binding posts, plainly marked positive and negative. More elaborate apparatus has an off and on switch and also automatic reels for the cords. Cords leading from the binding posts are flexible and are made up of insulated fine copper strands. The active electrode is connected to the negative pole and consists of a needle holder and needle. The dispersive or inactive electrode is connected to the positive pole, in turn connected to a sponge. The battery, rheostat, milliammeter, switch, binding posts and reels may be neatly mounted in a small box measuring approximately 12 inches in width, 10 inches in depth and 6 inches in height (fig. 1). The wiring diagram of a typical electrolysis unit is given in figure 2.

The needle holder should be light in weight, should be small and should grip the needle firmly. Some needle holders form a straight line with the needle. Others form a little more than a right angle to the needle. The latter holder is used by most dermatologists. A spring contact on the holder for making and breaking the current is a little bit cumbersome and awkward to operate. Either an insulated needle or a fine blunt pointed steel needle may be used for the removal of hairs. The insulation on a needle reaches within 1 mm. of the end, serving to concentrate the current at this point. Some dermatologists use platinum needles, but for the most part a steel needle is employed. Insulated needles have the advantage of causing less pain when a greater current is used. The point may be dull or sharp and is preferably rounded. The smallest and lightest needle obtainable is generally employed.

The dispersive or inactive electrode consists of a handle, insulated by wood and attached to a sponge

2. Michel, Charles E.: St. Louis Clin. Rec. 2: 145, 1875.

which is held in the patient's palm. Some physicians prefer to have the patient dip the hand in a saline solution, which is contained in a metal basin, in turn attached to the positive binding post of the apparatus. The milliamperage ordinarily employed varies between 0.25 and 1. For special conditions up to 2 milliamperes may be used. The milliamperage is controlled by a small rheostat and may be read on the milliammeter (fig. 1).

When using electrolysis for epilation, forceps which are light and flexible and which have a smooth grasping surface and tapering blunt points are preferred (fig. 3).

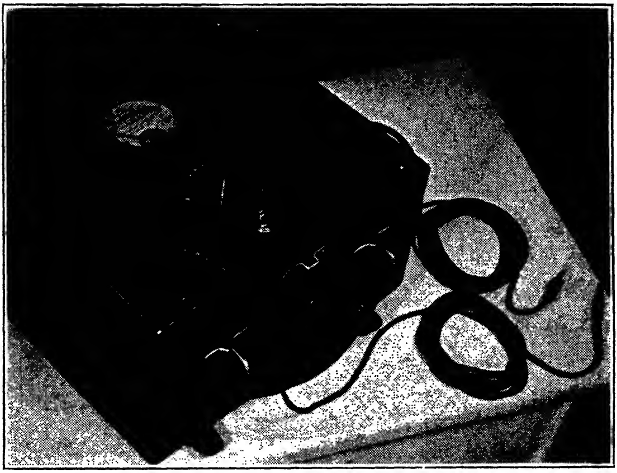

Fig. 1.—Electrolysis unit showing milliammeter, rheostat control, on-off switch and binding posts plainly marked for positive and negative (home-made equipment).

Every operator must be familiar with the method of testing his apparatus for polarity. This is done by attaching the needle to what is believed to be the negative pole. The sponge is attached to the positive pole. Then the two are inserted into a vessel containing water or physiologic solution of sodium chloride. Should small bubbles form around the needle (negative electrode) and rise to the surface of the water, correct polarity is indicated. If the needle and sponge were reversed, this bubbling would not be noticed. A faster method for determining polarity of a portable galvanic machine employs red litmus paper. When moistened

with distilled water, this will turn blue if touched with the negative pole of a direct current. It will not change color when in contact with the positive pole of a direct current. In performing this test, one must complete the circuit by drawing both electrodes across the paper. The importance of correct polarity must be emphasized, because if a steel needle were attached to the positive pole and inserted into the skin or follicular opening there would be a deposition of iron with the

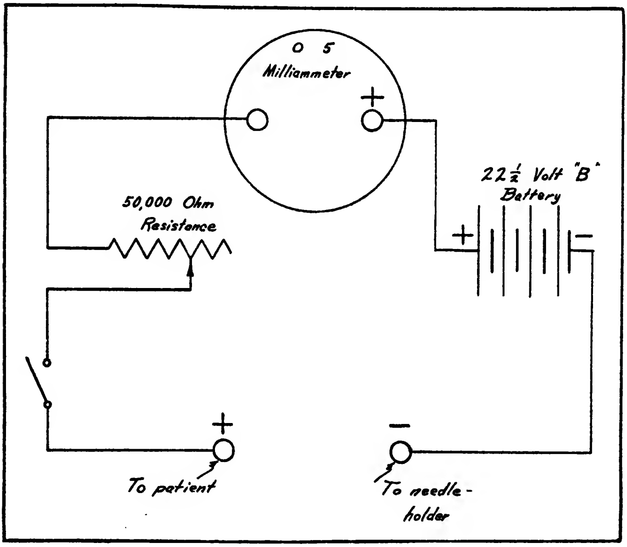

Fig. 2.—Wiring diagram of electrolysis unit.

resultant formation of a permanent iron tattoo mark, manifested as tiny black dots.

TECHNIC

The patient may lie on a flat table of a height convenient for the operator. Sometimes a special chair is used somewhat similar in type to that used by barber shops. The operator sits on a swivel stool in back of the patient, providing a resting place for his arms and hands. Artificial light is of the same intensity at all times and is therefore preferred to daylight. The light should be adequately and properly shaded and easily adjusted. Magnification is not essential but one having

poor eyes will find the Beebe binocular loupe helpful in treating small superficial lesions and fine hairs. The technic varies with the lesion treated.

For the removal of hair [3] the following method is employed by most dermatologists: The patient and the operator get in proper position, with the light adjusted (fig. 4). The area to be treated is first washed with soap

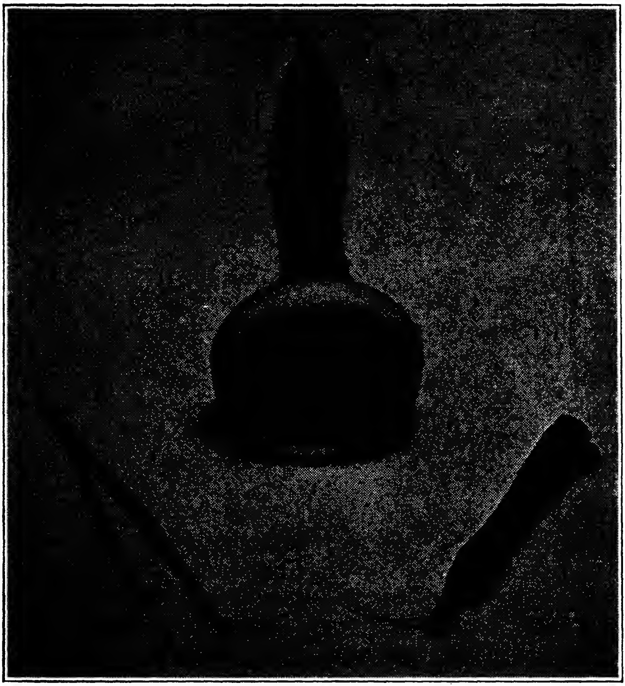

Fig. 3.—Sponge, needle-holder with needle in position, and forceps.

and water, and cleansed with benzine or carbon tetrachloride to remove all fatty substances. It is then dried with sterile gauze, and 70 per cent alcohol by weight is applied. The operator's hands are thoroughly scrubbed with soap and water and rinsed with alcohol. The needle is sterilized by immersion for ten minutes in alcohol and is attached to the negative terminal. The

3. MacKee, George M., and Cipbllaro, Anthony C.: Principles and Practice of Physical Therapy, Hagerstown, Md., W. F. Prior Company, vol. 1, chapter 18, p. 61.

needle holder must be clean and a surgically clean towel is put over the patient's eyes in order to protect them from the light and also for the deposition of removed hairs. The patient holds a wet sponge attached to the positive terminal in the palm of her hand. The operator is now ready to insert the needle into the follicle. That portion of the hair projecting above the surface of the skin is used as a guide for the needle. By delicate manipulation, the direction and the depth of the follicle are easily and quickly found. While the needle is held in place with the right hand, approximately 0.5 milli-

Fig. 4.—Patient lying on table and operator sitting behind patient in proper position for treatment.

ampere of current is allowed to act on the hair follicle. As a rule not more than one minute of time nor more than one milliampere of current is essential for this operation. Every few seconds the hair which is being treated is grasped by the forceps, which is held in the left hand, and a slight tug is given to the hair. If the hair has been thoroughly acted on by the galvanic current it will slide out of the follicle easily. The needle is then withdrawn. This process is repeated on the next hair. Contiguous hairs should not be removed, because the current is apt to set up a mild inflammatory condition of the skin preventing healing. As a rule not more than three or four hairs are removed from a dime

sized (18 mm. in diameter) area of skin. Dimpling of the skin, resistance to the entrance of the needle, edema, delayed appearance of the foam on the surface, excessive pain and muscular contraction indicate improper insertion of the needle. Experience and development of a fine sense of touch will tell the operator when he has reached the bottom of the follicle. No rule can be set down because the length of different follicles varies. The usual length of each treatment is approximately thirty minutes and the interval between treatments is approximately one week.

After the treatment the skin is swabbed with alcohol and dried, and calamine lotion with 1 per cent phenol is applied. Occasionally it is necessary to prescribe a mild lotio alba to be used at bedtime in order to prevent the formation of pustules. In order to obtain good cosmetic results the operator should observe the following rules:

1. Hairs should not be removed from inflamed areas.
2. A test treatment should be given to ascertain the toleration of the skin of various parts of the body.
3. One should always use the smallest amount of current that will effectively and permanently remove hair. A mild current usually suffices for the upper lip.
4. Contiguous hairs should not be removed at one sitting.
5. The needle should not be left in the follicle longer than is absolutely necessary.
6. The needle must pass through the orifice of the follicle and it must be in or very close to the hair bulb.
7. The parts to be treated should be cleansed first with soap and water, then with a fat solvent and finally swabbed with alcohol. After the treatment, an antiseptic shake lotion should be used for from twenty-four to forty-eight hours.

The proper control and manipulation of a single needle require the utmost muscular coordination, good eyesight, many months of experience and much patience. The difficulties encountered in controlling one needle are obvious. One can easily understand how much more difficult it would be to try to insert properly into the follicles and to control at the same time from eight to twelve needles. It therefore appears that the advantages claimed for the multiple needle method of electrolysis cannot be substantiated. What usually happens is that the needles are inserted into the skin and not into the follicles. It is very doubtful that more hairs are

removed in a given time by the multiple needle method than by the single needle method.

Anesthesia is not required. Various skin anesthetics are ineffectual. The discomfort after the first few treatments is really slight. Most patients soon get used to the treatments. The removal of hair by electrolysis can be mastered by most students. Some, however, are unsuited for this work because of temperament, poor eyesight, tremor or other physical defects. The work is exceedingly tedious, is very difficult and is a strain both physically and mentally.

The ordinary small pigmented hairy mole may be best removed by electrolysis. The hair is first removed as described. Then what remains of the nevus is treated by crisscross (transfixation) insertions of a sharp pointed, uninsulated, fine steel needle. At first the needle, held parallel to the skin, is inserted through the center of the lesion. Several insertions parallel to the first are made and, when the lesion is entirely covered, insertions are made at right angles to the first. During the entire procedure the needle is charged. For larger lesions 1 milliampere of current is used and for smaller ones from 0.5 to 0.75 milliampere is sufficient. The lesion is not completely destroyed at one sitting. Several sittings at weekly or bimonthly intervals are necessary. The average mole requires from three to four treatments. Successive treatments are not given until after the reaction from the previous treatment subsides. The treatment of nevi should not be entrusted to lay operators because they lack the requisite knowledge to differentiate benign moles from those which may be actuated into malignant neoplasms by trauma. Even a physician who is well trained, undertaking the treatment of moles with electrolysis, should satisfy himself of the nature of the lesion.

The technic for the treatment of dilated capillaries differs from that used in hypertrichosis and nevi. Dilated capillaries occur in rosacea, in nevus araneus, following overexposure tc radium or x-rays, and in other conditions. These telangiectatic vessels are quickly cured by electrolysis. The needle is inserted vertically in several places along the course of the vessel. For small capillaries, single insertions are sufficient. When treating a spider nevus, the needle is inserted vertically in the center of the lesion and is allowed to stay in

place for about a minute. At the end of this time the area appears slightly edematous and blanched, having the appearance of a wheal following an insect bite. When treating telangiectasis by electrolysis, following overexposure to radium or x-rays, one must be extremely careful as to how the treatment is applied. Energetic treatment may break down the radiodermatitic tissues, resulting in ulcer formations. Since the vessels are quite superficial, the needle need not be inserted deeply.

The small common wart and venereal, flat, filiform and digitate warts can be permanently and completely destroyed by inserting the needle vertically into the center of the lesion or by the crisscross (transfixation) method as described under the treatment of nevi.

Senile and seborrheic keratoses that have not undergone epitheliomatous transformation are occasionally treated by electrolysis. The method employed is the same as that for verrucae. Benign new growths such as adenoma sebaceum, multiple benign cystic epithelioma, tricho-epithelioma, syringocystadenoma and hydrocystoma are often cured by treatment with electrolysis. Slightly raised lesions that are small may be treated by vertical insertions, whereas the larger lesions are treated by transfixation of the needle.

It is advisable to discuss at this point the many serious conditions that result from improperly performed electrolysis. This procedure is widely used by laymen, most of whom are unqualified because of lack of experience and training. They work under such misleading names as electrologists, hair specialists, dermatologists and beauty culturists. Some lay operators become very proficient in the mechanical handling of the needle but they lack the necessary training that would enable them to differentiate benign from malignant lesions, to avoid infection, to institute proper antisepsis and to prevent disfiguring scars. A lay operator taught by a physician and working under the supervision of a physician and qualified by training and experience is invaluable. Electrolysis involves not only the actual manipulation of the needle holder as is taught by many commercial houses but also a fundamental knowledge of many phases of medicine, including anatomy and bacteriology. This knowledge is possessed only by physicians.

SCARS AND PITS

The permanent disfigurements of scars and pits probably result more frequently than any of the other complications. Those possessing inadequate knowledge or who are not experienced and poorly trained generally apply too much current or leave the current on too long. More often in treating hypertrichosis the electrically charged needle is not in the follicle and several insertions through the skin produce scars and pits. This permanent damage of the skin frequently affects the patient psychologically. Some persons become introspective and may even develop a mild inferiority complex. The return of the hair adds considerably to the mental agony of these patients and may cause them to become psychopathic.

INFECTION

A complication that also occurs frequently is infection. As a rule only a small pustule develops where the needle was inserted. This may result from improper sterilization of the needle, inadequate sterilization of the integument, improper cleansing of the hands of the operator or lowering of the resistance of the skin by the combined trauma of the electric current and the insertion of the needle. Occasionally more profound infections may occur, even to the point of causing abscess formation. It is even possible for erysipelas to develop around one of these infected areas. When the infection occurs in the nose, on the upper lip and over the glabella it may be so serious as to cause death, since there is a direct venous communication between these areas and the lateral sinuses. Expert medical operators will never traumatize the tissues within the nose and will not remove hairs from the glabella, eyebrows and upper lip without careful preliminary practical sterilization of the hands, affected areas and their instruments.

EDEMA, BLOOD AND PAIN

The improper insertion of the needle may cause an edematous reaction around the needle. When this occurs while one is treating hypertrichosis the needle should be withdrawn because it is not in the hair follicle. A small droplet of blood appearing around the needle indicates that a small blood vessel has been punctured. In some cases ecchymotic areas and pigmentation occur. Pain is more severe in highly sensitized persons than

in others. It is also more marked when electrolysis is performed on a patient who has had insufficient sleep or is fatigued from other causes. Excessive pain is experienced when too much current is used or when the needle pierces the skin or goes through the hair follicle. In certain idiosyncratic individuals tiny depigmented areas around the follicular openings may occur and in others even tiny keloids may develop. It is therefore important that some time elapse between the first and the second treatment, so that the physician may have an opportunity of observing the results of the first treatment. It is also essential that the first treatment be a short one so that the patient will gradually become accustomed to the operation.

MISTAKEN DIAGNOSIS

Many dermatologists have had brought to their attention patients with malignant neoplasms who were treated for something else by electrolysis. There should be no difference of opinion among physicians as to the undesirability of lay operators without medical supervision using methods that may not only fail to cure the condition but actually lead to serious sequelae. Frequently basal cell epitheliomas may have the general appearance of a fibroma, a nonpigmented nevus or even a pigmented nevus. Only a dermatologist is capable of diagnosing these conditions, and sometimes the differential diagnosis is so difficult that it is necessary to remove tissue for a microscopic examination. It is necessary to state here that electrolysis is not the proper method of treating pigmented and nonpigmented basal cell epitheliomas. Even more serious than this, there are some pigmented lesions which are called benign melanomas. As long as these lesions are not traumatized they remain benign, but as soon as they are treated by such inadequate methods as electrolysis they become malignant and metastases may occur in remote areas of the body within a short time. Angiosarcomas have similarly been mistaken for benign moles with the same serious consequences. Lewis [4] mentions a case in which a syphilitic gumma was treated several times by means of electrolysis.

4. Lewis, George M.: Electrolysis in Skin Disorders, M. J. & Rec. **134**: 234 (Sept. 2), 272 (Sept. 16) 1931.

The technic for the removal of hair is much the same as that used with the galvanic current. It is important that before inserting the needle into the follicle that no current flows. After the needle has been inserted the current is turned on with one or two short (about ½ second) pressures on the footswitch. The needle is removed after turning off the current. The hair should be ready to slide out of the follicle with little or no pull.

The advantages of removing hair by the high frequency method over electrolysis are several. In the first place many more hair follicles may be destroyed in unit time. The pain accompanying high frequency depilation is of short duration, although its intensity might be greater. The amount of irritation of the skin is about the same with both generators. With carefully applied technic, there is only slight irritation. Scarring is avoidable. When scars occur, it is usually the result of repeated applications of the needle and of the current after failing to remove the hair after the first trial. There should be no scarring with either electrolysis or with high frequency depilation. There is always a certain amount of regrowth following treatment. However, according to my personal observations over a period of several years, the amount of hair that returns after treatment is about the same with either method. The outstanding advantage of electrocoagulation is that of time saving.

The question of removing hair by means of high frequency currents has often come up. So far the attitude of most dermatologists has been one of extreme caution. It can now be said that the removal of unwanted hair by means of electrocoagulation is a safe procedure provided that the operator is skilful and the apparatus suitable. In the past, apparatus has been effective in construction and the regulatory devices have been too coarse. A unit suitable for the removal of superfluous hair with electrocoagulation has been described in a recent article by Karp.[5] Another excellent article bearing on this subject is that written by Lerner.[6]

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5. Karp, Florentine L.: High Frequency Current in the Treatment of Hypertrichosis, Arch. Dermat. & Syph. **43**: 85 (Jan.) 1941.

6. Lerner, Charles: The Treatment of Hypertrichosis by Electrocoagulation, N. Y. State Jour. of Med. **42**: 879 (May) 1942.

Most high frequency generators of the spark gap type with a highly damped oscillatory current and with a frequency of one to 3 million cycles per second should be suitable provided that a potentiometer is used between the apparatus and the patient for fine adjustment of the current. The exact settings to be employed are determined by the trial and error method. Once the settings are ascertained, they need not be changed except for unusual situations. Bipolar technic is employed.

CONCLUSION

It should be pointed out that electrolysis is a valuable agent for the treatment of many conditions. It is the only agent that will safely and adequately cure hypertrichosis. Carelessness, inexperience and ignorance have caused undesirable injuries to the skin and other serious consequences. The operator must have at least an elementary knowledge of the anatomy of the skin, of bacteriology, of antisepsis, of tissue tolerance to trauma, of the chemical reaction involved in electrolysis, of the physics and mechanics of the apparatus used. He must know especially how to differentiate benign lesions amenable to electrolytic treatment from potentially dangerous lesions which they simulate. It is obvious that this modality can be properly used only by physicians qualified by training and experience or under their direct supervision.

40 East Sixty-First Street.

SOURCES OF ULTRAVIOLET AND INFRA-RED RADIATION USED IN THERAPY

PHYSICAL CHARACTERISTICS

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Prominent among the panaceas to relieve people's ills and to keep them in health are sources of ultraviolet and infra-red rays. The mere mention of "infra-red rays" creates in the mind of many persons a feeling that this is something new and mysterious that they have missed, when, as a matter of fact, it is difficult to think of a warm object that does not emit infra-red rays.

When an object is heated to a higher temperature than its surroundings, an excess of infra-red rays passes from it to the surrounding objects. Examples of sources of infra-red rays are arc lamps, incandescent lamps, coal fires, steam pipes and hot stoves. Because of their low temperature, the infra-red rays emitted by hot water bags and electrical heating pads are of low intensity, and hence they are insignificant in comparison with the amount of heat that is obtained by conduction, by having the hot pad or hot water bottle in contact with the body. Of course it sounds more impressive to speak of infra-red rays than to speak of the application of heat by conduction, by direct contact of the pad with the body.

There is nothing new or mysterious about the ultraviolet and the infra-red rays. A person is always exposed to the infra-red rays when standing near a steam radiator, an open grate fire or even an electric toaster. The spectral quality and total intensity of the infra-red rays emitted by the electric radiant heaters for warming rooms is essentially the same as emitted by the infra-red lamps sold for therapeutic purposes except that the latter have smaller reflectors and have more elaborate adjustable mountings, which cost more money.

During the past few years, experimental data have become available showing that the spectral band of

ultraviolet radiation of wavelengths shorter than about 3,150 angstroms,[1] occurring in sunlight and in some artificial sources of radiation, if sufficiently intense and if the time of exposure is sufficiently prolonged, has the power of preventing and of curing rickets. This is the underlying basis for exploiting ultraviolet of these wavelengths for general healing purposes. While this point of view may be too broad, the beneficial effects of short wavelength ultraviolet radiation in surgical tuberculosis and certain skin diseases is recognized.

Before I discuss the various types of sources of radiation available for therapeutic purposes, it will be instructive to consider several incidental questions that enter into the subject. In fact, in order to apply radiation therapy successfully, it is important to have a thorough understanding of the physical properties of the source of thermal radiation as well as the physiologic reaction of living matter when exposed to it. Successful phototherapy depends on a knowledge of the spectral quality of the source, the total quantity or intensity, and the time of exposure, which depends on the distance of the patient from the lamp.

Excepting for the question of intensity and wavelength, physically there is no marked distinction between the various regions of the spectrum called "ultraviolet," "visible" and "infra-red." Chemically and physiologically there is a distinct difference. The action of infrared rays is thermal and instantaneous, producing a burning sensation when the intensity is too great. On the other hand, the ultraviolet rays are actinic, causing, among other effects, the coagulation and precipitation of albumin. Their action is slow and insidious, so that the effect is not perceived until from three to six hours after exposure. A short exposure to an innocent-looking carbon or mercury arc may produce severe conjunctivitis. Hence the eyes should be protected with deep brown glasses or covered with a black cloth to prevent injury when the body is being irradiated.

Although there is no sharp demarcation of these rays into wavelength bands, for convenience I shall indicate these spectral ranges (table 1) and mention some of the photochemical and physiologic effects, if known. The wavelengths may be written in angstroms, microns

1. The angstrom unit of wavelength is one ten-millionth millimeter.

($\mu = 0.001$ mm.) or millimicrons (mμ); i. e., wavelength 3,000A $= 0.3\,\mu = 300$ mμ. Thus the ultraviolet emission line of the quartz mercury vapor arc lamp, frequently mentioned in this paper, is 2,967 angstroms, 0.2967 micron or 296.7 millimicrons. More complete data on the radiation from arc lamps [2] and on their germicidal action [3] are given in other publications.

1. *Depth of Penetration of Thermal Radiation.*—Authorities differ regarding the transparency of the skin, muscles, tendons, etc., and, hence, the depth to which radiation of different wavelengths can penetrate into the body.

Recent transmission measurements seem to indicate that the depth of penetration is not so great as formerly supposed. Furthermore, with increase in knowledge of radiation therapy, less emphasis is being placed upon this question.

Depth of penetration is a relative term, whether we mean penetration to a depth where the intensity is reduced to $\frac{1}{10}$ or $\frac{1}{10,000}$ of the incident radiation; and this, in turn, depends upon the threshold of the biological effect sought, whether photochemical action, temperature rise, heat sensation, etc.

For example, when a flash-lamp is placed in the mouth, in the palm of the hand or against the inside of the wrist, when viewed in the dark, the cheeks, the frontal sinuses, the back of the hand and the outside of the wrist glow with a reddish light, showing that the light of the lamp, somewhat modified by selective absorption in the short wavelengths, and much reduced in intensity (and diffused over a much wider area than the part illuminated) has traversed a thickness of, respectively, 5 to 40 millimeters.

Spectral transmission measurements on samples of different thicknesses of skin are in agreement with similar measurements on more homogeneous samples of other proteins, showing great opacity to ultraviolet radiation of wavelengths shorter than about 3,000 angstroms and to infra-red radiation of wavelengths

2. Coblentz, W. W.; Dorcas, M. J., and Hughes, C. W.: Radiometric Measurements on the Carbon Arc and Other Light Sources Used in Phototherapy, Bur. Stds. Sc. Papers **21**: 535, 1926 (No. 539, 15 cents). The Bureau of Standards publications are obtainable only from the Superintendent of Documents, Washington, D. C., at the prices indicated.

3. Coblentz, W. W., and Fulton, H. R.: A Radiometric Investigation of the Germicidal Action of Ultra-Violet Radiation, Bur. Stds. Sc. Papers **19**: 641, 1924 (No. 495, 20 cents).

longer than about 25,000 angstroms (beyond which wavelength water also is very opaque), so that in neither case can an appreciable amount of radiation penetrate to a depth greater than about 0.05 to 0.1 mm. Nevertheless, the ultraviolet rays can produce a photochemical action on substances in the skin, and thereby have a specific healing value.

TABLE 1.—*Different Spectral Regions, Probable Depth of Penetration and Probable Physiologic Action of Rays from Different Sources* *

Spectral Region	Penetration of Rays	Physiologic Action	Source
Short ultraviolet 1,800 to 2,700 A	Superficial 0.01 to 0.1 mm.	Photochemical (vitamin D producing); bactericidal; erythemal; slight pigmenting	Metals in carbon arc and spark of metals (mercury arc)
Therapeutic or middle ultraviolet 2,700 to 3,200 A	Superficial 0.1 to 0.5 mm.	Photochemical; maximal erythema and pigmenting; vitamin D producing	Sun; high pressure mercury arc; impregnated carbon arcs
Long ultraviolet 3,200 to 3,900 A	Superficial 0.5 to 1 mm.	Photochemical; pigmenting ("tanning"); thermal	Sun; metals in carbon arc; arc of metals
Visible spectrum 3,900 to 7,600 A	Deep 1 to 10 mm.	Thermal; nerve stimulation	Sun; carbon arc; incandescent lamps
Short infra-red 7,600 to 15,000 A	Deep 10 to 1 mm.; decreasing with increasing wave length	Thermal; nerve stimulation	Sun; carbon arc; gas-filled tungsten lamp and carbon filament incandescent lamp
Long infra-red 15,000 to 150,000 A	Superficial 1 to 0.05 mm.	Thermal; nerve stimulation	Carbon arc; low temperature radiant heater

* Wavelengths in angstroms, A.

On the other hand, so far as is known, the effect of infra-red radiation is entirely thermal. Recent studies of temperature sensation, by Oppel and Hardy [4] show that nonpenetrating infra-red radiation, of long wavelengths, is the most stimulating. This probably explains why discomfort is sometimes experienced when one is exposed to certain types of heaters, which emit an excessive amount of nonpenetrating infra-red radiation.

4. Oppel, T. W., and Hardy, J. D., Jr.: Studies in Temperature Sensation. I, A Comparison of the Sensation Produced by Infra-red and Visible Radiation. Clin. Investig. **16**: 517 (July) 1937.

The part of the spectrum to which the skin is relatively transparent (but in which there appears to be no specific biologic action other than nerve stimulation) extends from about 5,000 angstroms to 12,000 angstroms, with a wide maximum of transparency in the region of 7,000 to 9,000 angstroms.

This is the spectral region of "penetrating radiation," the depth of penetration depending upon the nature of the underlying material (tendon, blood vessels, muscle), as for example, the irradiated hand, the back of which, as already mentioned, shows a reddish glow, and dark shadows of the superposed blood vessels.

According to Oppel and Hardy,[4] the more penetrating the rays the less sensitive is the subject to them. However, the amount of irradiation, even with penetrating wavelengths, that can be tolerated by the skin is rather low, so that this form of internal heating is different from that obtained with diathermy machines. By irradiating the body with a source emitting a large amount of penetrating radiation Laurens and Foster[5] obtained a measurable increase in temperature (about 1 C. at a depth of 15 mm. below the surface) above that attained when exposed to an equal amount of non-penetrating infra-red radiation.

Data on the depth of penetration of radiation into the skin are given in table 1. It is, of course, to be understood that small amounts of radiation penetrate to still greater depths than here indicated and that these values represent limits in depth at which effective biologic action (if any) may still be expected. In the dehematized skin the depth of penetration would be greater than under normal conditions.

2. *Reflectors and Windows.*—In view of the fact that most lamps used for therapeutic purposes are provided with reflectors and windows, it is relevant to emphasize the fact that the mirror acts solely as a reflector of the rays that fall on it and does not itself contribute anything additional to the ultraviolet radiation emitted by the source. In fact, since the reflector absorbs more of the short wavelength ultraviolet than of the visible and infra-red rays, especially when the surface is composed of a powdered metal (for example, aluminum) which

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5. Laurens, H., and Foster, P. C.: The Effect of Artificial Radiant Energy on the Tissue Temperature Gradient in Men of Different Skin Colors and After Artificial Pigmentation, Am. J. Physiol. **118**: 372 (Feb.) 1937.

has been applied with a lacquer, the total amount of ultraviolet radiation in proportion to the visible and the infra-red rays is relatively lower in the reflected rays than in those that proceed directly from the source. The reflector, placed back of the source, simply increases the total amount of radiation of all wavelengths falling on an object placed in front of the lamp. The reflector cannot supply ultraviolet wavelengths that may be lacking in the source, and after it becomes covered with smoke from the arc, the amount of reflected radiation is, of course, greatly reduced.

Likewise windows or filters used in front of the source of ultraviolet, whether it is the sun, the mercury arc or the carbon arc, emit no ultraviolet wavelengths themselves but always reduce the intensity of the rays that are present. The same is true of lacquers used in applying the powdered metal for a reflecting surface. Linseed oil and cellulose lacquer are highly opaque to ultraviolet radiation of wavelengths shorter than 3,500 angstroms.

3. *Radiant Heat Versus Conducted Heat.*—Owing to the general misconceptions on this subject, it is relevant to call attention to the difference in heat transfer by conduction and by radiation. Practically all the heat obtained from an electrically operated heating pad or a hot water bottle (which takes the place of a heated brick or of ground meal used in the earlier days), placed in contact with the body, is transferred by thermal conduction. The amount obtained in the form of infra-red rays is negligibly small.

SOURCES OF RADIATION

Under the caption of sources of radiation various types of thermal radiators are considered, beginning with those operated at low temperatures and therefore emitting principally infra-red rays. In order to obtain an appreciable amount of ultraviolet radiation it is necessary to heat the radiating substance to a high temperature, 3,000 C. (5,432 F.) or higher. Since solids (e. g., metals such as tungsten) evaporate rapidly at high temperatures, sources of ultraviolet radiation are practically confined to electric arcs between electrodes of metals and of carbon in air, and of mercury vapor in a closed tube of quartz glass called "the burner."

1. *Miscellaneous Sources.*—Under this caption may be grouped vacuum incandescent lamps, kerosene lamps, acetylene flames, luminous and Bunsen gas flames, and incandescent mantles heated by gas flames, which do not emit sufficient ultraviolet radiation to be useful in therapy. Neither is the ultraviolet emitted of sufficient intensity to be a source of injury to the eye. Vacuum incandescent lamps have been built into cabinets used for treatment by means of infra-red rays. Wood and coal fires, in an open grate, emit practically no ultraviolet radiation but are good sources of infra-red rays, which will become less and less familiar to coming generations. The open-front gas stove, with its incandescent radiant of refractory clay, cannot be operated at a sufficiently high temperature to emit an appreciable amount of short wavelength ultraviolet rays. It is a convenient source of intense infra-red radiation, giving a spectral energy distribution that is somewhat similar to curve *B* in chart 1. However, care should be taken to avoid the production of carbon monoxide which results from improperly adjusted gas burners and insufficient ventilation.

2. *Infra-Red Radiators.*—Under this caption may be placed various radiant heaters used for therapeutic purposes. They consist of a concave reflector at the focus of which is an incandescent filament lamp in a glass bulb, or a heater consisting of an electrically heated solid rod, or a resistance wire embedded in or wound on an electrically nonconducting refractory material, such as, for example, steatite, "lava" or porcelain. The color of the surface (whether white or black) is unimportant. The nonmetallic surface emits the greatest amount of infra-red rays.

The incandescent carbon and tungsten filament radiators that are enclosed in glass bulbs emit radiation of wavelengths 5,000 to 40,000 angstroms (chart 1), with the maximum emission at from 11,000 to 20,000 angstroms, depending on the temperature of the filament. Only a small amount of radiation is emitted by the glass bulb.

The radiant heaters that are not enclosed in glass emit perceptible radiation of all wavelengths throughout the infra-red to 150,000 angstroms (15 μ in the illustration), beyond which point the intensity is very low, as shown in chart 1. The carbon dioxide and water vapor

in the air selectively absorb certain wavelengths in the infra-red, producing indentations in the spectral energy curves, especially at 4.2 microns (42,000 angstroms), as shown in this illustration. With increase in temperature the maximum emission shifts toward the short wavelengths, so that for a surface temperature of from 300 to 400 C. (572 to 750 F.) the maximum emission (curve *C*, chart 1) is not well defined, extending from 4 to 5 microns (40,000 to 50,000 angstroms), whereas at a low red heat (from 600 to 800 C., or 1,112 to 1,472 F.) the maximum emission becomes more sharply defined

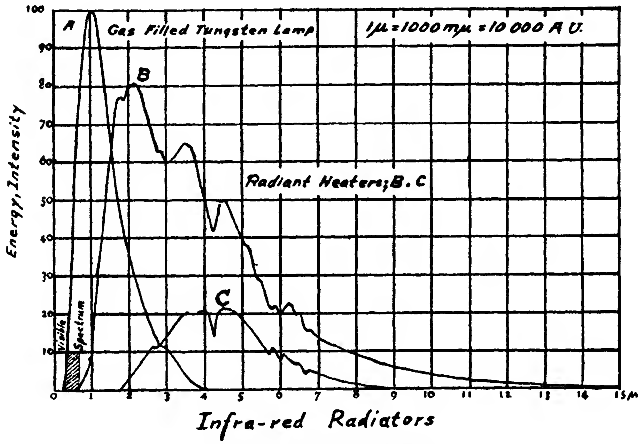

Chart 1.—Infra-red radiators

(curve *B*, chart 1) and lies between 2 to 3 microns (20,000 to 30,000 angstroms). Moreover, the infra-red radiation from the latter is far more intense (eight to ten times greater) than that emitted by the heater at 300 C. (572 F.).

The reflectors surrounding these heaters are practically nonselective; hence they have no appreciable effect in modifying the spectral composition of the radiation emanating from the heater. In other words, there is no way of producing narrow spectral zones of radiation by emission in the infra-red. On the other hand, filters for isolating relatively narrow bands of the visible and ultraviolet are easily provided.

For experimental purposes, the most easily produced, fairly narrow band of infra-red radiation is obtainable

from the Bunsen nonluminous gas flame, which has a strong emission band at 4.4 microns (44,000 angstroms), but the total intensity is rather low.

A filter consisting of a cell of water and red glass will confine the radiation stimulus to the spectral region extending from 6,000 to 14,000 angstroms. The red glass alone will confine the stimulus to wavelengths between 6,000 and 40,000 angstroms. Such a filter may be used in front of a Mazda, gas-filled tungsten lamp as a source of infra-red rays.

3. *The Tungsten Filament Lamp.*—The "Mazda" tungsten filament lamp, enclosed in a bulb of special glass that transmits ultraviolet at wavelengths extending from 2,800 to 3,100 angstroms (recognized as effective in preventing rickets) has been considered for a source of ultraviolet radiation. A small lamp, similar in appearance to the automobile headlight lamp, was on the market some time ago. It was operated at a considerably higher voltage than that normally used, which shortened the useful life to a few hours. It was claimed that under these conditions the lamp would emit sufficient ultraviolet radiation for therapeutic purposes. The lamps examined did not emit an appreciable amount of ultraviolet rays of wavelengths less than 3,100 angstroms.

Calculations and radiometric measurements show that the tungsten filament lamp, even when enclosed in a bulb that transmits the ultraviolet rays extending from 2,800 to 3,100 angstroms, emits but little ultraviolet radiation of these wavelengths.

In curve *A* of chart 1 is depicted the relative spectral energy distribution of the radiation from the gas-filled tungsten lamp. The maximum emission occurs at 10,600 angstroms (1.06 μ in the illustration).[5a] The measurements were made on a 1,500 watt gas-filled lamp, but without a reflector such as is used in a therapeutic lamp. The reflector would increase the total intensity in the direction observed. The bulb, which was of clear glass, absorbs practically all the radiation of wavelengths longer than 35,000 angstroms and it absorbs completely all the radiation of wavelengths greater than 45,000

5a. The spectral energy distribution of a helical carbon filament lamp is similar to curve A in chart 1, with the maximum emission at 1.5 to 1.8 μ, and a relatively higher intensity than the tungsten filament, at 2 to 2.5 μ.

angstroms. The low temperature radiation from the heated glass bulb (some 11 per cent of the total) cannot penetrate deeply into the skin.

The gas-filled tungsten lamp is useful as a source of visible and of short wavelength infra-red radiation of wavelengths less than 15,000 angstroms. About 30 per cent of the total radiation emitted by the gas-filled tungsten lamp is of wavelengths that can penetrate deeply into the skin. However, this type of lamp cannot be used in place of a short-wave diathermy machine to produce heating deep within the human tissue. For example, operating a 1,500 watt carbon filament lamp so close that the heat blistered the skin raised the temperature less than 0.5 F. at a depth of 2 inches below the surface. The original papers cited here[6] contain data on the spectral energy distribution of the tungsten filament in a gas-filled bulb.

A recent production that is still in an experimental stage of development is a tungsten filament in a gas-filled bulb of black or blue glass that freely transmits the infra-red rays and absorbs the visible rays, thus reducing the glare of the intense white light.

4. *The Violet Ray Lamp.*—One of the standard products of commerce is an incandescent lamp consisting of a helical carbon filament in a bulb of blue glass, sold for decorative purposes and sources of low illumination in assembly rooms. If such lamps have a therapeutic effect, e. g., in stimulating the growth of hair on bald heads, it should be noticeable on patrons of amusement houses. Nevertheless such lamps have been put into special caps and sold for growing hair and for therapeutic purposes.

Radiometric tests showed that the intensity of the violet and ultraviolet rays emitted by such a lamp is only one ten-thousandth the total radiation emanating from the lamp. The amount of violet and ultraviolet rays of full sunlight transmitted through the glass bulb of such a lamp was from 1,000 to 1,500 times greater than that of the carbon filament lamp. Observations showed that the intensity of the violet rays of sunlight (skylight) falling on the scalp of a person sitting near a window,

6. Coblentz, W. W.: Emissivity of Straight and Helical Filaments of Tungsten, Bur. Stds. Sc. Bull. **14**: 115, 1917 (No. 300, 5 cents). Priest, I. G.: Bur. Stds. Sc. Papers, Measurements of the Color Temperature of the More Efficient Artificial Light Sources by the Method of Rotary Dispersion **18**: 225, 1922 (No. 443, 5 cents).

but not in direct sunlight, would be from 50 to 150 times that of a blue bulb carbon filament lamp.

Another bit of hokum is a so-called violet ray lamp, consisting of a spark coil to which is attached a glass tube that terminates in a flattened glass bulb, which emits a blue glow when it touches the body. The function of this glass tube is to provide a high resistance to the electric current that comes from the spark coil, so that the patient will not feel the shock too severely. Even if the ultraviolet rays generated could pass through the glass walls of the bulb, they would be too weak in intensity to be effective for therapeutic purposes.

5. *The Nickel and the Tungsten Arc.*—The radiation emitted from the arc vapors between two electrodes of nickel, and of tungsten, consists of numerous fine lines which (chart 2) are not separated when examined with a small spectroscope.

The spectral energy distribution of the arc between two pure nickel rods, 12 mm. in diameter, with tapered ends, operated on 6 amperes, is given in chart 2, from which it may be noted that the nickel arc emits strongly at 230 millimicrons (2,300 angstroms) and especially at 350 millimicrons (3,500 angstroms). These bands are especially conspicuous in certain cored carbons, discussed in a subsequent part of this chapter. The arc of nickel-cored carbons is an excellent source of ultraviolet radiation. Moreover, the material is inexpensive, quiet burning and easy to operate.

The tungsten rods examined were 6.4 mm. in diameter and were the regular imported British stock material used for therapeutic purposes. They were operated on 5 amperes. Because of the formation of a crust of oxide around the electrode, the arc was rather unsteady and hence difficult to operate. The emission spectrum of tungsten is weak in the spectral region of wavelengths shorter than 2,300 angstroms (230 mμ in the illustration).

The odors from the metal arcs are disagreeable, and some vapors may be irritating to the bronchial tubes. In order to eliminate the odors and to secure greater steadiness in operation, cored carbon electrodes containing oxides of certain metals are commonly used in place of electrodes of pure metals.

6. *The Sun.*—In connection with the following discussion of the radiation emitted by artificial sources, it is relevant to mention the sun—the only natural source available for therapeutic purposes. The temperature of the surface of the sun is above 5,500 C. (9,932 F.), some estimates being 6,000 C. (10,832 F.). The solar radiation intensity, falling on a surface normal to the incident rays in this latitude (38° 50′) at sea level at the noon hour on a clear day, amounts to about 1.2 Gm.-calories per square centimeter per minute and rarely rises to 1.35 Gm.-calories. Less than 0.1 per cent of this amount is ultraviolet of wavelengths that have a strong therapeutic action, at least in preventing rickets.

The intensity of the ultraviolet rays varies greatly with the altitude above sea level (chart 3) and also with

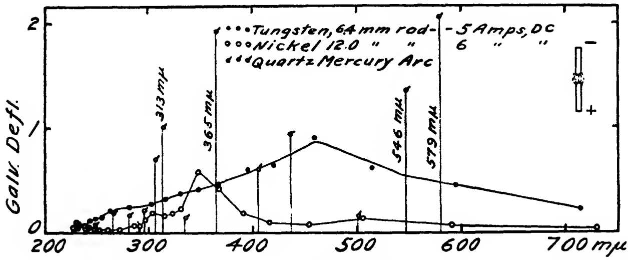

Chart 2.—Spectral energy (intensity, galvanometer deflections); distribution of the radiation emitted by the arc between electrodes of nickel, of tungsten and of mercury vapor in a quartz tube, called "the burner."

the time of day. Only between the hours of 9 a. m. and 3 p. m. (excepting in the three summer months, when least needed) is this ultraviolet component of sufficient amount to be of importance radiometrically, and probably therapeutically. In addition to this variation with the time of day, the amount of vitalizing ultraviolet solar rays available for therapeutic purposes varies with the season of the year, with the altitude and the geographic latitude of the station, and with the almost infinite variety of air pollution and weather conditions that are encountered in different localities.

The intensity of the shortest ultraviolet solar rays transmitted by the atmosphere is extremely small. The intensity at 2,900 angstroms is only one millionth as great as at 3,130 angstroms, where the mercury arc has a strong emission line, and only about one forty-mil-

lionth of the intensity of the sun's rays in the visible spectrum, where the intensity is a maximum (chart 3).

7. *The Carbon Arc.*—As already mentioned, the temperature of the surface of the sun is about 5,500 C. (about 9,900 F.). The temperature of the positive electrode of the carbon arc is much lower—about 3,300 C. (about 6,000 F.). The carbon arc is the hottest artificial source of radiation readily obtainable, and in this respect it is the closest approach to sunlight. However, the radiation from the carbon arc is far from being like sunlight. There is a strong emission band in the violet at about 3,890 angstroms (the "cyanogen band," chart 3), and beyond 40,000 angstroms in the infra-red there is a great amount of radiation not present in sunlight. When a window of special glass (e. g., Corex-D) is used, which shuts out the ultraviolet rays of wavelengths shorter than 2,900 angstroms and longer than 40,000 angstroms, the spectral limits are similar to those of sunlight; but the intense cyanogen band remains.

Except for the violet cyanogen band at 3,890 angstroms, the vapors from the electrodes of pure carbon are quite nonluminous. A highly luminous arc is produced with carbons filled with various substances.

Superimposed on the radiation from the arc vapors is the continuous spectrum from the highly incandescent crater of the positive electrode. The result is an intense infra-red spectrum, of wavelengths longer than the solar rays transmitted by the atmosphere. If the arc is surrounded by a glass or a quartz globe, as already mentioned, some of the infra-red rays are excluded; but in turn the surrounding globe becomes heated and emits nonpenetrating infra-red rays with wavelengths of from 50,000 to 120,000 angstroms, which are not present in sunlight. Hence, no exact comparison can be made between the radiation from the sun and the carbon arc.

The crater of the positive electrode emits an intense white light, which, as already mentioned, is mixed with the radiation of the arc vapors. This fact is usually overlooked in discussions of the radiation from the carbon arc. The vapors from the pure carbon arc contribute but a small amount to the total radiation emitted.

In chart 3 is shown the distribution of energy in the ultraviolet and in the visible spectrum of the sun

(as observed on Mount Wilson) and of the white flame carbon arc. For convenience in making these comparisons, the radiation intensities (the galvanometer deflections) of the sun and of the carbon arc were set to equality at 300 millimicrons (3,000 angstroms), a procedure that is permissible and in common use.

No appreciable radiation of the sun of wavelengths less than 2,900 angstroms is transmitted by the earth's atmosphere. On the other hand, radiation of wavelengths out to 2,200 angstroms is observable in the white flame carbon arc. As illustrated in chart 3, the ultraviolet cyanögen band, with its maximum emission at 389 millimicrons (3,890 angstroms), is relatively

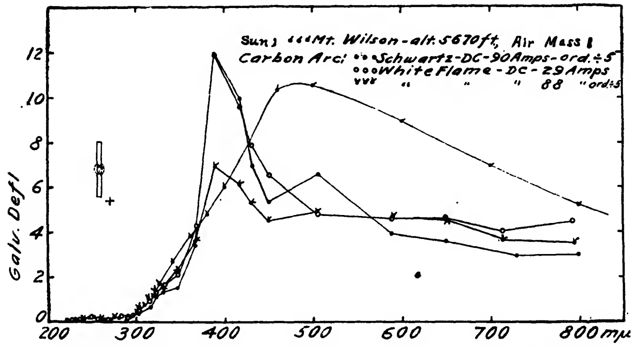

Chart 3.—Spectral energy (intensity) distribution of the sun and of the carbon arc.

far more intense than similar wavelengths in the spectrum of the sun. On the other hand, under the same conditions, the radiation of the sun in the visible spectrum is relatively far more intense than that which obtains in the white flame carbon.

As will be mentioned presently, the radiation from the mercury vapor arc in a quartz burner consists of a series of strong emission lines, notably at 2,537, 2,660, 2,804, 2,967, 3,024, 3,132, 3,342 and 3,663 angstroms. In this spectral region the radiation from the vapors of the carbon arc consists of numerous fine lines, which are so close that the spectrum appears continuous and, hence, somewhat like that of sunlight.

When the carbon arc is enclosed with a close-fitting transparent quartz chimney, the gases surrounding the arc expand and force sufficient air out of the chimney

to establish an equilibrium in pressure; viz., atmospheric pressure. The amount of oxygen is reduced and the life of the electrode is prolonged. When the arc is extinguished, cold air rushes in. This does not mean, however, that the arc was operating under reduced pressure; i. e., in a partial vacuum. The pressure was the same as, or slightly above, the atmospheric pressure, but the volume of oxygen (air) was reduced.

In some recent designs of carbon arc lamps the arc is partly surrounded by a metal casing, which reduces the air circulation and prolongs the life of the electrode.

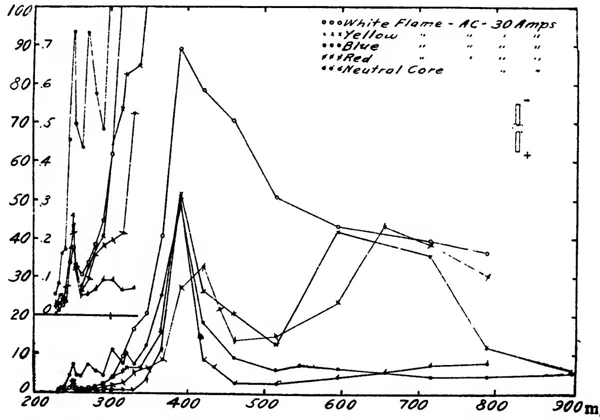

Chart 4.—Spectral intensity (energy) curves of different kinds of carbon electrodes.

Factors Affecting Carbon Arc Radiation: It has been found that the radiation from the carbon arc depends on (1) the size and the kind of the electrodes (white flame, blue flame, yellow flame, red flame, chart 4); (2) the direction of the current when direct current is used through combinations of neutral cored and impregnated carbons, and (3) the amount of electric current.

This information has been of assistance in making improvements in arc lamps. Assuming that the manufacturer has incorporated into his lamp the latest improvements based on the information available regarding the proper current, the proper size of electrode for a given current, and the direction of the current (if direct current) through the electrodes, it is incumbent on the purchaser of such a lamp to operate

it as was intended. This is evident from the increase in the intensities (galvanometer deflections) of the different wavelengths with increase in the current (hence the temperature) in the arc (chart 5). These curves are called "isochromatics," meaning at some particular wavelength.

Amount of current. Take for example, the curve of intensities for the wavelength 3,024 angstroms, which is of special interest because of its strong antirachitic action. On 5 amperes the galvanometer deflection was hardly perceptible. With a current of from 25 to 30

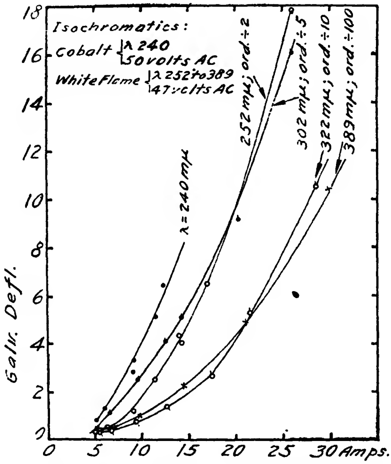

Chart 5.—Increase in intensities of the emission lines in the carbon arc with increase in current.

amperes, the intensity (galvanometer deflection) was almost 100 times greater.

Size of electrodes. Suppose the operator is using carbon electrodes about 12 mm. in diameter, which require from 25 to 30 amperes in order to attain the proper temperature. It is evident that on 10 amperes (the maximum commonly available on house circuits) he would obtain less than one-tenth the intensity available. Moreover, the arc would sputter and would burn unsteadily. To avoid sputtering, when used on a current of 8 to 10 amperes, the electrodes of carbon arc lamps should be only 6 to 8 mm. in diameter.

As a general rule, high amperage arcs are more efficient than the low amperage arcs in the production

of ultraviolet and visible radiation, relative to the total infra-red radiation produced. All carbon arcs emit considerable nonpenetrating infra-red radiation of wavelengths longer than 40,000 angstroms not present in sunlight. Aside from the production of a sensation of warmth, there is probably no important physiologic reaction that could not be produced by the above-described, simpler sources of infra-red radiation.

Data on the radiation from the carbon arc have been published elsewhere.[7] To simplify the discussion, it will be sufficient to depict the spectral energy distribution of representative samples of cored carbons containing substances that, in the state of incandescent vapor, have bands of selective emission in certain parts of the spectrum. These spectral energy curves, throughout the ultraviolet, the visible spectrum from 390 to 750 millimicrons (3,900 to 7,500 angstroms) and to 800 millimicrons (8,000 angstroms) in the infra-red spectrum, are illustrated in chart 4. The inset on the left-hand side of chart 4 gives a magnified (ten times) illustration of the intensities extending from 250 to 300 millimicrons.

Direction of current. The carbon electrodes used were 12.7 mm. in diameter and were operated on 30 amperes, alternating current. The effect of direct current is to raise the temperature of one electrode considerably higher than the average that obtains when alternating current is used. This increases the intensity of the cyanogen band at 3,890 angstroms, especially in the blue flame arc, but it does not have so marked an effect on the intensity of the radiation in the short wavelength ultraviolet and in the visible spectrum.

Kind of electrodes. It may be noticed (chart 4) that in the neutral core carbon arc (a practically pure carbon) the ultraviolet radiation of wavelengths less than 320 millimicrons (3,200 angstroms) is extremely weak, the radiation being concentrated almost entirely in the cyanogen band, with a maximum at 389 millimicrons (3,890 angstroms). In contrast, in the blue flame ("therapeutic B") carbon arc, the ultraviolet radiation of wavelengths less than 310 millimicrons (3,100 angstroms) exceeds that of all the other arcs illustrated (chart 4.).

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7. Coblentz, W. W.: Spectral Characteristics of Light Sources and Window Materials Used in Therapy, Tr. Illum. Engin. Soc. **23**: 247 (March) 1928. Coblentz, Dorcas and Hughes.[2]

In the yellow flame ("therapeutic D") carbon arc there is considerably more radiation, extending from 2,900 to 3,200 angstroms (290 to 320 mμ in the illustrations) in the ultraviolet, which is weak in the neutral core carbon arc. In the visible spectrum there is a strong emission extending from 5,000 to 7,500 angstroms.

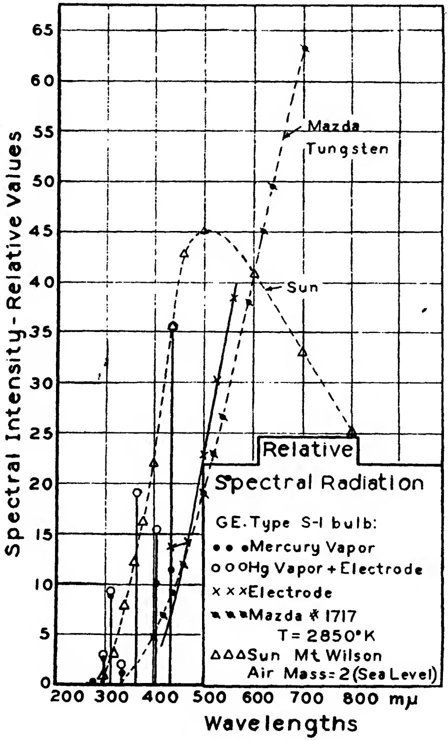

Chart 6.—Relative spectral radiation.

The red flame ("therapeutic E") carbon arc is conspicuous for its intense emission, extending from 5,500 angstroms in the orange to beyond 7,500 angstroms in the red.

The white flame ("therapeutic A") carbon arc is conspicuous for its relatively low spectral emission in the ultraviolet of wavelengths shorter than 2,900 angstroms, its high emission in the region extending from

4,500 to 5,000 angstroms, which is lacking in the other carbon arcs just described. Owing to the intense radiation in the cyanogen band at 3,890 angstroms (chart 3), the color of the light emitted by the white flame carbon is a more bluish white than sunlight. However, as already mentioned, when the arc is covered with a suitable glass chimney, which absorbs the ultraviolet rays shorter than 2,900 angstroms and the infra-red rays longer than 40,000 angstroms, the white flame carbon arc is the closest approach to sunlight. But it is still far from being an exact match with sunlight in spectral energy distribution. It remains to be determined whether this difference in spectral energy distribution is of importance biologically.

8. *The Quartz Mercury Arc.*—The radiation from the mercury arc, in a quartz tube called "the burner," is emitted principally in a series of intense spectral lines (charts 2 and 6) superposed on a faint continuous spectrum that contributes but little to the total ultraviolet emanating from the arc.

Recently a number of new types of mercury arc lamps have been put on the market. They serve two purposes: (1) those emitting a high ultraviolet intensity, for therapeutic purposes, and (2) the so-called sunlamps, which emit practically no radiation of wavelengths shorter than 2,800 angstroms, sold to the public for home use without the supervision of an experienced physician.

The Hot Quartz Lamp: The earliest and best known type of quartz mercury arc lamp (the so-called hot quartz lamp) operates at a high vapor pressure and a relatively high temperature. The current through the lamp is fairly large (from 3 to 4 amperes) and the voltage on the burner is low (from 65 to 70 volts).

Investigations [8] of quartz mercury arc lamps having (1) a solid tungsten anode and (2) a liquid mercury anode show that there is no appreciable difference in the ultraviolet component radiation emitted by these two types of lamps when operated on the same energy input in the burner. Air-cooled burners operated on alternating current (through the burner) and water-

8. Coblentz, W. W.; Long, M. B., and Kahler, H. K.: The Decrease in Ultraviolet and Total Radiation with Usage of Quartz Mercury Vapor Lamps, Bur. Stds. Sc. Papers **15**: 1, 1918 (No. 330, 5 cents). Coblentz, W. W., and Kahler, H. K.: A New Spectropyrheliometer and Measurements of the Component Radiations from the Sun and from a Quartz Mercury Vapor Lamp, Bur. Stds. Sc. Papers **16**: 233, 1920 (No. 378, 5 cents).

cooled burners operated on direct current appear to have a somewhat higher ultraviolet radiation component than air-cooled, direct-current burners, owing to the lower temperature of the lamp.

A recent development is a mercury arc lamp, operated on alternating current, in which both (Wehnelt) electrodes are of activated metal. The burner, of quartz or thin Corex-D glass, contains only a small amount of mercury which is completely vaporized. The emission spectrum is typical of the ("hot quartz") neutral mercury atom.

Aside from several strong emission lines in the region of 10,000 to 12,000 angstroms, the quartz mercury arc emits but little infra-red radiation.[9] The infra-red rays that are emitted emanate principally from the incandescent tungsten anode and especially (in both types of lamps) from the quartz enclosure and the hood, which emit low temperature, long wavelength, nonpenetrating radiation.

Physically there is no comparison between this type of radiation and that of the sun (chart 7), and it is hardly to be expected that these two sources will give the same results in all types of light treatment, and in dye fading.

In chart 7 is given the spectral energy distribution (unshaded vertical lines) of a 110-volt vertical Uviarc lamp operated on 65 volts, and about 4 amperes in the burner. Owing to the high current density, the temperature and the pressure are relatively high, and the resonance emission line at 2,537 angstroms is practically of the same intensity as the lines at 3,024 and 3,132 angstroms, in contrast with the so-called cold quartz vapor glow lamp (chart 7), in which the line at 2,537 angstroms contains over 95 per cent of the radiation emitted by these three lines.

The Mazda Sunlight Lamps: A modification of the "hot quartz" mercury arc (the Mazda S-1 and the Mazda S-2 "sunlight" lamps) is a combination of an incandescent tungsten filament and an arc in mercury vapor between highly incandescent electrodes of tungsten. This is accomplished by operating a V-shaped helical tungsten filament in parallel with the mercury arc, but it is at a considerably lower temperature

9. Coblentz, W. W.: Selective Radiation from Various Substances, IV. Bur. Stds. Sc. Bull. 9: 96, 1912 (No. 191, 10 cents).

than the incandescent tungsten electrodes forming the arc at the top of the V-shaped filament. The surrounding globe, of Corex-D glass, absorbs the rays of wavelengths shorter than 2,800 angstroms which are not present in sunlight. The mercury arc supplements the ultraviolet radiation, which is only feebly emitted by the incandescent tungsten electrodes, at from 2,800 to 3,650 angstroms.

The result of this combination of incandescent solid and arc-vapor radiation is an unusual emission spectrum, consisting of a series of strong ultraviolet emission lines of mercury vapor (at 2,804, 2,967, 3,024. 3,132, 3,342, 3,663 and 4,078 angstroms, chart 6). superposed on a continuous spectrum radiation from the incandescent solid, which increases rapidly in intensity (beginning to be perceptible at about 3,650 angstroms) and extends throughout the visible and into the deep infra-red (charts 1 and 6).

A recent production is the type S-4 lamp, operated on alternating current. The lamp consists of a high intensity mercury arc between activated tungsten electrodes, in a quartz capillary tube that is inclosed in a glass bulbs which absorbs the rays of wavelengths shorter than about 2,800 angstroms. The erythematogenic efficiency of the S-4 lamp is appreciably higher than the S-1 lamp.

The "Cold Quartz" Lamp: The so-called cold quartz ultraviolet lamp is essentially a low vapor pressure, low amperage (0.015 ampere), high potential (5,000 volts, open circuit), glow discharge, similar to the well known Geissler tube. The power consumed is small and consequently there is no great rise in temperature of the burner.

The spectral energy distribution of this type of ultraviolet lamp is illustrated in chart 7. Of the total radiation of all wavelengths shorter than and including the line at 3,132 angstroms, more than 95 per cent is contained in the resonance emission line of mercury vapor at 2,537 angstroms. Two models of this type of lamp were examined—a small grid hand lamp in an aluminum reflector and a large hexagonal grid lamp in a large aluminum reflector, supported on a stand for body irradiation.

The erythematogenic efficiency of this type of lamp is high, but, as shown in chart 7, practically all the

erythemal effect is produced by the line at 2,537 angstroms. For this reason the question has arisen whether this type of ultraviolet radiation should be used for general body irradiation or whether its application should be confined to special conditions. The fact that the erythematogenic efficiency of a source is high is not necessarily a criterion of its suitability for therapeutic purposes.

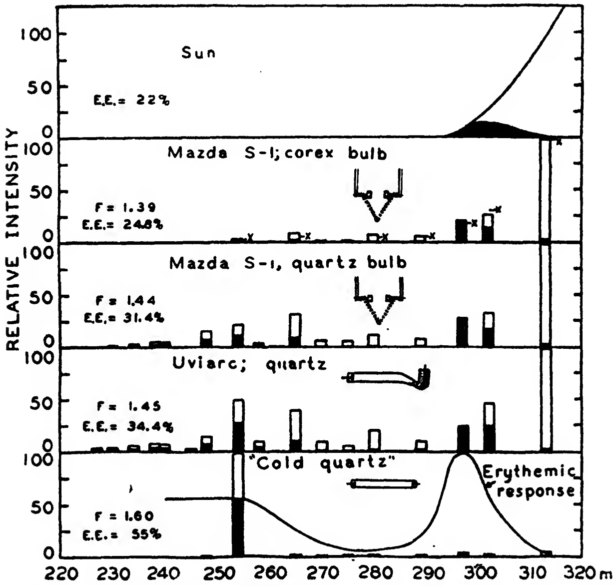

Chart 7.—Ultraviolet spectral energy distribution of various sources; also spectral erythemic response curve of the untanned skin and (the shaded areas) the rubescence energy which is the product of the spectral energy and the spectral erythemic response. E. E., erythematogenic efficiency; the ratio of the shaded area to the total area.

A recent application of this type of lamp (in quartz, or in a glass that is highly transparent to radiation at 2537 angstroms) is for disinfecting purposes. (See discussion applicability and shortenings in the "Acceptance" by the C. P. T., J. A. M. A., Jan. 24, 1942, Vol. 118, pp. 298-299.)

The Type G Mercury Glow Lamp: By providing suitable ionization by means of electrons emitted from a hot cathode, only a relatively low voltage is required to excite resonance radiation in the glow discharge

through mercury vapor. A typical example of this type of radiation is an ultraviolet glow lamp in a pear-shaped bulb of special glass that absorbs almost completely all the ultraviolet rays of wavelengths shorter than about 2,800 angstroms. The operating temperature of this type of lamp is low, and the glow discharge practically fills the glass bulb.

The spectral energy distribution of this type of mercury vapor radiation is somewhat similar to that of the Mazda S-1 lamp in a Corex-D glass bulb, illustrated in chart 7. Since the total ultraviolet emitted by this type of lamp is of wavelengths longer than 2,900 angstroms, it belongs to the category of "sunlamps."

The High Frequency Electrodeless Discharge: Another type of ultraviolet therapeutic lamp is the electrodeless discharge through mercury vapor, in a spherical bulb. The lamps examined were spherical bulbs of quartz, or Corex-D, glass (without electrodes), which are placed within a helical conductor that carries the high frequency current, obtained from the transformer of a diathermy machine. The bulb is evacuated and contains a globule of mercury, the vapor of which is excited to luminescence by means of the high frequency discharge from the 5,000 volt secondary of the transformer, passing through the helix surrounding the bulb. It is well known that the emission spectrum of the electrodeless discharge is essentially that of the neutral mercury atom, similar to that of the ordinary mercury arc, though close to the walls of the bulb there are some weak spark lines, not present in the hot quartz mercury arc lamp.

The spectral energy distribution, the total ultraviolet output, and the erythematogenic efficiency of this type of lamp were found to be closely the same as that of the ordinary mercury arc lamp (Uviarc) depicted in chart 7. Practically the only difference is the intrinsic brightness (flux density), which, in the ordinary quartz mercury arc, is concentrated in a luminous column less than 10 mm. in diameter, whereas in the electrodeless discharge the radiation fills the entire bulb, some 6 to 8 cm. in diameter.

9. *The Cold Red Light.*—But few sources of radiation remain unexploited for therapeutic purposes. A recent European production is the so-called cold red light emitted by the neon glow discharge tube, familiar

to all in the form of the sign-lighting tubes in show windows and street signs. The intensity of the total radiation emitted by the neon glow lamp is low. It consists of a narrow band of wavelengths in the orange-red part of the spectrum, with a maximum in the region of 6,500 angstroms, and a weaker maximum at about 8,500 angstroms. Neon emits practically no radiation of wavelengths longer than about 10,000 angstroms.[10] If the deep-penetrating rays in the red and near infra-red have a specific therapeutic action, it would be more efficient to use a more intense source of these rays. For example, a powerful source of red and near infra-red rays is a 500 watt gas-filled tungsten filament lamp described on a preceding page. If the narrow band of red and near infra-red rays has a specific therapeutic action only when used separately from the rest of the spectrum of the tungsten lamp, it can be isolated by placing in front of the lamp a filter consisting of a sheet of red glass to shut out the shorter wavelengths, and a cell of water or a sheet of Corning heat-absorbing glass to intercept the infra-red rays of wavelengths longer than about 10,000 angstroms. (See, however, the abovementioned objectionable features and shortcomings, page 10). The maximum of the filtered radiation will be in the spectral region of about 7,000 to 8,000 angstroms, with an intensity that far exceeds the ordinary neon glow lamp. From the clinical tests made by Cramer and Fechner [11] with a neon glow lamp, made for therapeutic purposes, it appears that the cold red ray lamp has little, if any, specific stimulating effect on the human body.

BIOLOGIC EFFECTS

This survey of the ever increasing number of types of lamps sold for therapeutic purposes, some of which are so weak in ultraviolet radiation that an exposure of from ten to thirty hours would be required to produce a minimum perceptible erythema, seems incomplete without some reference to their use.

As noted on a preceding page, during the past few years experimental data have become available which show that the spectral band of ultraviolet radiation

10. Coblentz, W. W.: Selective Radiation from Various Substances, IV, Bull. Bur. Stds. **9**: 93, 1912 (No. 191, 10 cents).

11. Cramer, H., and Fechner, G.: Clinical Tests of Skin Reaction to Cold Red Light (Neon). Strahlentherapie **39**: 474, 1931.

of wavelengths shorter than about 3,150 angstroms, occurring in sunlight and in some artificial sources of radiation, if sufficiently prolonged, has the power of preventing and of curing rickets. This is the underlying basis for exploiting ultraviolet of these wavelengths for general healing purposes. Whether this point of view is too broad remains to be determined.

An important unanswered question is the minimum ultraviolet radiant flux (radiant power) that the source must emit in order to insure effective therapeutic action. Manifestly, the amount of ultraviolet radiation that can be applied to the body without producing a burn depends on the tolerance of the skin. This can be measured by the erythema produced. It is common knowledge that the erythemal sensibility of the untanned skin is widely different for different persons and also widely different for the same person, depending on the amount of moisture on the skin. Hence, the erythemic response is in common use as an indicator of skin tolerance and of the amount of ultraviolet radiation that can be applied at any one time. Furthermore, in view of the wide variation in ultraviolet output of different kinds of lamps, and the wide variation in skin tolerance (twice as sensitive in summer as in winter), the safe procedure is to test the erythemal reaction on a small area of each person before attempting to make exposures over large areas of the body.

Since most of these sources emit a wide band of ultraviolet radiation in the spectral region that produces an erythema (shown in the lower part of chart 7), the purpose of the erythema test is to avoid burns. The erythema test is not necessarily a measure of the therapeutic action of the lamp, although, in the case of rickets, the spectral bands of erythemal and therapeutic action appear to overlap. However, if a source should be obtained having a strong emission at from 2,700 to 2,900 angstroms with little or no radiation at 2,500 and 2,967 angstroms (lower part of chart 7), a far stronger dosage than with lamps now in use could be applied, without producing a burn.

In view of these considerations[12] the Council on Physical Medicine of the American Medical Association

12. Coblentz, W. W.: Ultraviolet Radiation Useful for Therapeutic Purposes, J. A. M. A. **98**: 1082 (March 26) 1932; **99**: 125 (July 9) 1932.

has adopted [13] and, until a more practical procedure is proposed, will use the erythemal reaction as a basis for judging the effectiveness of ultraviolet lamps for two important reasons: (1) In the case of exposure to intense sources of ultraviolet radiation it is a simple and practical means of preventing severe burns, and (2) in the case of weak sources of ultraviolet radiation it is an efficient safeguard against possible fraudulent sale of lamps that are deficient in ultraviolet radiation.

The Council's specifications of minimum intensity are based on a comfortable and convenient operating distance (24 inches, or 61 cm.) from the front edge of the reflector, at which distance the exposure can be made without burning the skin by coming in contact with the burner or by the infra-red rays. The ultraviolet intensity of the lamp shall be such that the time of exposure to produce a minimum perceptible erythema (one that disappears in less than twenty-four hours) will not be longer than fifteen minutes for a therapeutic lamp and sixty minutes for so-called sun-lamps.

As shown in chart 7, the emission line of the mercury arc lamp at 2,967 angstroms (297 mμ in the illustration) has an erythematogenic efficiency of 100 per cent relative to the rest of the spectral erythemic response. No other wavelength or group of wavelengths has such a high efficiency in generating an erythema. Hence the emission line of homogeneous radiation at 2,967 angstroms is a natural standard for evaluating sources of heterogeneous ultraviolet radiation.

The intensity and the erythematogenic action of the emission line of mercury at 2,967 angstroms is easily evaluated in absolute units; and the erythemal action, as well as the radiometric output, of the heterogeneous ultraviolet radiation from various sources is readily correlated with this emission line as a standard.[14]

From our experiments [14] it appears that a fifteen minute exposure to a flux density of 20 microwatts per square centimeter (or a total of 180,000 ergs) of homogeneous radiation of wavelength 2,967 angstroms does

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13. Acceptance of Sunlamps, J. A. M. A. **102:** 42 (January 6) 1934; **114:** 325 (January 27) 1940.

14. Coblentz, W. W.; Stair, R., and Hogue, J. M.: Tests of a Balanced Thermocouple and Filter Radiometer as a Standard Ultraviolet Dosage Intensity Meter, Bur. Stds., J. Research **8:** 759, 1932 (R. P. No. 450, 10 cents).

not produce an erythema on the average untanned skin, though it may be somewhat too intense for a blond skin.

The Council has therefore adopted 10 microwatts per square centimeter of homogeneous radiation of wavelength 2,967 angstroms as the erythemal unit (E. U.) of dosage intensity[13]; that is, 1 E. U. = 10 microwatts per square centimeter of radiation of wavelength 2,967 angstroms. For a further discussion of this subject the reader is referred to the original papers.[13, 14]

With 20 microwatts per square centimeter (2 E. U.) of homogeneous radiation of wavelength 2,967 angstroms as a standard, in table 2 are given the erythematogenic equivalents of the heterogeneous (the total integrated) ultraviolet radiation of wavelengths shorter than and including 3,132 angstroms required of various sources to produce a minimum perceptible erythema on the average untanned skin in fifteen minutes. For an exposure of sixty minutes the minimum permissible values are only one-fourth as large. That is to say, the total energy of unit intensity (20 microwatts per square centimeter) falling on a surface in fifteen minutes is the same as when one-fourth the intensity (5 microwatts per square centimeter) is used and the surface irradiated sixty minutes, or four times as long. From this table it may be noticed that the lower the erythematogenic efficiency of the source, relative to the standard line at 2,967 angstroms, the greater must be the total ultraviolet intensity of wavelengths shorter than and including 3,132 angstroms in order to meet the Council's requirements.

The specification of intensities given in table 2 are average values, observed in a 0-5 degree zone subtended by the center as the source; i. e., within a circle approximately 4 inches (10 cm.) in diameter, lying in a plane at right angles to the axis of the reflector, at the specified operating distance (24 inches, 61 cm.) from the front edge of the reflector; it constitutes the minimum values accepted by the Council on Physical Therapy.

In concluding this discussion it is relevant to emphasize the importance of protecting the eyes from injury (conjunctivitis), which is caused by ultraviolet rays of wavelengths shorter than about 2,900 angstroms.

This applies to all sources of ultraviolet that are not enclosed in glass bulbs, or are not covered with glass windows that absorb ultraviolet radiation of wavelengths shorter than about 2,900 angstroms.

Furthermore, ultraviolet lamps that are not thus inclosed in glass should be operated in large well venti-

TABLE 2.—*Erythematogenic Equivalents of Heterogeneous Ultraviolet Radiation From Various Sources, Relative to 20 Microwatts per Square Centimeter of Homogeneous Radiation of Wavelength 2,967 Angstroms, Required to Produce a Minimum Perceptible Erythema*

Source	Microwatts per Square Centimeter
Homogeneous radiation of wavelength 2,967 angstroms only (mercury vapor arc)	20
Sun: midday, midsummer, midlatitude, sea level	91
Carbon arc: blue flame, cored carbon, in reflector, no window	48
Carbon arc: glass window, opaque to 2,800 angstroms and shorter (estimated)	90*
Mercury arc: Mazda, type S-1 lamp; high temperature arc in parallel with V-shaped tungsten filament; in glass bulb	83*
Mercury arc: Mazda, type S-2 lamp; similar to the S-1 lamp, but smaller; in glass bulb	93*
Mercury arc: quartz capillary; type S-4; in glass bulb	80*
Mercury arc: type G-5; low temperature, low voltage thermionic glow discharge; glass bulb	108*
Mercury arc: high temperature, high vapor pressure, low voltage; quartz tube	58
Mercury arc: high frequency electrodeless discharge; quartz bulb	60
Mercury arc: low temperature, low vapor pressure, high voltage, "cold quartz," Geissler tube discharge	36

* Lamps marked with an asterisk are acceptable as sunlamps.

lated rooms to keep down the concentration of ozone, which is generated by the radiation at 2,200 angstroms (and shorter wavelengths) strongly emitted by mercury arc lamps especially by lamps of the "cold quartz" type in which all the mercury is vaporized—also in the "hot quartz" type on first starting the lamp.

In concentrations of about one part per million by volume, ozone irritates the respiratory passages, and causes coughing, headaches, etc., depending upon the time of exposure. Ozone is far more dangerous than

carbon monoxide.[15] Fortunately its presence is easily detected by the pungent, irritating odor, in concentrations far lower than the injurious dose.

CONCLUSIONS

It may be stated that in general the lamps submitted to the Council have an intensity that is several times the minimum requirements tabulated. The operating distance and the time of exposure to a given type of lamp are specified by the manufacturer.

In the newer lamps, such as the G-type glow lamp, the first productions did not comply with the specifications, but these lamps were promptly improved to meet competition with other types.

In general, the specifications by the Council have tended to improve the output of responsible lamp manufacturers, but at present there seems to be no means to prevent the exploitation of the public by the sale of cheap lamps emitting little or no ultraviolet radiation; and by so-called "sun lamps" which emit ultraviolet radiation of wavelengths shorter than 2,900 angstroms (not present in sunlight) that are dangerous because they produce conjunctivitis and, with excessive exposures, may cause (cataract) coagulation of albumin.

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15. Henderson and Haggard: Noxious Gases, Monograph 35, American Chemical Society. The Truth About Ozone, editorial, J. A. M. A. **61**: 1045, Sept. 27, 1913.

THE THERAPEUTIC VALUE OF ULTRAVIOLET RADIATION

COUNCIL ARTICLE

The Council on Physical Medicine recognizes the place of ultraviolet radiation therapy in medical practice. However, it is also cognizant of the fact that this type of therapy is often exploited beyond its limitations. The following statements set forth the views of the Council with respect to the conditions in which ultraviolet radiation therapy is of benefit:

Either natural or artificial heliotherapy is used. The artificial sources of therapeutic ultraviolet radiation are the carbon arc lamp, the low voltage (hot) mercury vapor lamp and the high voltage (cold) mercury glow lamp. For further information on the artificial sources of ultraviolet radiation the reader is referred to the chapter "Sources of Ultraviolet and Infra-Red Radiation Used in Therapy—Physical Characteristics," by W. W. Coblentz, Ph.D., D.Sc., in this book on page 244.

VITAMIN D [1]

Ultraviolet irradiation with wavelengths shorter than 3,130 (particularly 2,967) angstroms exerts an influence on calcium and phosphorus even when the diet is adequate.[2] But of even greater importance from the standpoint of protection against dietary deficiencies is the action of ultraviolet radiation in rectifying partial lack of the components necessary for proper calcification of bone and teeth.[3]

From the provitamins in the skin, ultraviolet irradiation gives rise to vitamin D, the agent which promotes normal calcium anabolism and retention of phosphorus. Therefore it may prevent and cure rickets, adult as well as infantile, promote growth and prevent excessive loss of lime from the body. It is necessary not only for the development of teeth but for their protection later in life.

Ultraviolet irradiation may be used in the treatment of infantile tetany, a symptom complex occurring in rickets when the

1. Laurens, Henry: Physiologic Effects of Ultraviolet Radiation, J. A. M. A. **111**: 2385 (Dec. 24) 1938.

2. Laurens, Henry: Physiological Effects of Radiant Energy, New York, Chemical Catalog Company, Inc., 1933, pp. 257, 261.

3. Laurens: Physiological Effects of Radiant Energy, p. 285; Photochemistry in Medicine: A General Outline, in Cold Spring Harbor Symposia on Quantitative Biology, Cold Spring Harbor, L. I., N. Y., the Biological Laboratory, 1935, vol. 3, p. 277; Sunlight and Health, Scient. Monthly **42**: 312 (April) 1936. Bunker, J. W. M., and Harris, R. S.: New England J. Med. **216**: 165 (Jan. 28) 1937.

blood calcium is low. The treatment of choice is a combination of a calcium salt (lactate or gluconate), a diet low in phosphate and optimal vitamin D.[4] Latent tetany may become manifest when rachitic infants are irradiated if sufficient calcium is not available, owing to the suddenly increased mobilization and deposition of calcium in the growing bones.

While irradiation of parathyroidectomized animals and man will keep them free from tetany, administration of vitamin D itself is far more efficient.

When an animal is irradiated, its skin, liver, fat and muscle become antirachitically active.[5] Ultraviolet radiation forms vitamin D either in the cells of the living organism or in its foodstuffs. Direct exposure of the skin to ultraviolet rays from the sun or from artificial sources results in the formation of vitamin D within the organism, but the Council cannot recognize statements or implications that ultraviolet radiation from an artificial source has all the beneficial effects of exposure to sunshine.

The Council on Foods and Nutrition has made the decision that for the present milk is the only common food which will be considered for acceptance when fortified with vitamin D. One of the methods used to impart antirachitic properties to accepted vitamin D milks is irradiation with ultraviolet shorter than 3,130 angstroms. Activation depends on the same wavelengths effective directly in the cure and prevention of rickets.

Vitamin D in some way regulates the passage of calcium and phosphorus across the intestinal wall. It exerts its action by raising the blood calcium and/or phosphate. This is associated usually with an increased net absorption from the intestine, though under certain circumstances the bones may provide the calcium and phosphate. The net retention of the animal as a whole is the resultant of two opposing factors: (1) increased absorption from the intestine or diminished excretion to it and (2) increased excretion by the kidney. As the dosage of vitamin D becomes larger, the second factor overtakes the first.

TUBERCULOSIS [6]

Both natural and artificial ultraviolet radiation are of definite value in the treatment of some forms of tuberculosis. There is still considerable difference of opinion on which regions of the light spectrum are most efficacious as well as confusion as to the tuberculous conditions that respond best to this treatment.

Natural heliotherapists, especially those working in high altitudes, emphasize solar radiation and aerotherapy. On the other hand, those in cloudy climates have stressed the use of artificial lights and still others, on occasion, the x-rays.

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4. Laurens: Physiological Effects of Radiant Energy, p. 334; Photochemistry in Medicine;[3] Sunlight and Health.[3]
5. Laurens: Physiological Effects of Radiant Energy, pp. 347, 389; Photochemistry in Medicine;[3] Sunlight and Health.[3]
6. Mayer, Edgar: Light Therapy and Roentgen Therapy in Tuberculosis, J. A. M. A. **105**: 1599 (Nov. 16) 1935.

The physiologic effects of radiant heat energy suggest that clinical results of therapy with sunlight are at least in part dependent on the red and infra-red region. Most recently the response of certain forms of superficial tuberculosis, especially of the skin, to heat radiation speaks very clearly for this.

The exact part played in the clinical usage of radiation by the total visible spectrum is difficult to say, although in all probability it is in some way physiologically effective.

In tuberculosis, on the basis of the quality of ultraviolet wavelengths and of the results obtained at the seashore, at inland sea level and in the mountains, Danish workers are convinced that ultraviolet energy of the region longer than 313 millimicrons is the one effective in the treatment. The additional part played by the action of moving air on the skin in the solar treatment of extrapulmonary tuberculosis must not be discredited. Probably the combination of all factors contributes to the end result.

The radiations of artificial sources represent approximations to sunlight, and no two sources are alike in respect to the distribution of the energy they emit. Therefore, different sources do not produce the same physiologic or therapeutic action. The energy emitted by various artificial sources varies in intensity and in spectral distribution. The intensity of the radiation of sunlight on the earth's surface varies considerably, particularly on account of location, season and time of day. It will vary as much as 5 per cent in total intensity and a variation of five to ten times in noon hour ultraviolet winter to summer.

For therapeutic purposes the sun, the mercury vapor arc in quartz and the flaming carbon arc burning cored carbons filled with mixtures of carbon dust and metals have been found to be most practical. The mercury vapor lamp has been particularly developed for its emission of ultraviolet, although it also emits well in the visible part of the spectrum. Its ultraviolet component represents between 9 and 28 per cent of the total energy of all wavelengths emitted by the lamp. A carbon arc consuming 25 amperes or more and burning specific carbons, such as "sunshine" carbons, closely approximates highland sunshine. Carbon arcs of varying amperage and with special cored carbons will emit, almost according to the needs, widely varying intensities in many regions of the spectrum.

An important question in the selection of these various sources of light is the minimum ultraviolet radiant power that a source must emit in order to insure effective therapeutic action. The amount of ultraviolet that can be applied to the body without producing a burn depends on the tolerance of the skin. The erythemal reaction is really the only physiologic one that is established with a relatively high degree of accuracy. As a criterion it is a simple and practical means of preventing severe burns and as a reaction it is a good means of judging the effectiveness of a lamp.

The conditions, clinical and otherwise, indicating the selection of one source of light in preference to others depend in part also on the convenience of usage, the availability of the source of light and the cost of running. In the past, carbon arc lamps of high amperage have been more generally applied for exposures of groups. The mercury quartz lights are now applicable for exposures of groups as well as individual patients. The carbon arcs of lower amperage, as well as mercury arcs, can be used for single patients. Irradiation with artificial light, as ordinarily employed indoors, lacks some apparently important accompaniments of outdoor solar exposures, such as constantly moving fresh air.

Pulmonary Tuberculosis.—For uncomplicated pulmonary tuberculosis, no clinical evidence is at hand to prove the indication for ultraviolet radiation. The lack of accurately controlled observations among certain workers makes it necessary to accept their favorable reports most cautiously. Until contrary evidence is at hand, ultraviolet irradiation is contraindicated in the treatment of uncomplicated exudative pulmonary tuberculosis. Sunlight or artificial light, if employed at all, should be used cautiously in the treatment of proliferative or fibrotic pulmonary tuberculosis, which may be accompanied by elevation of temperature. Intense sunlight should be avoided, and diffuse daylight or early morning and late afternoon sunlight should be watched for. The indications here resemble those of tuberculin therapy.

In pulmonary tuberculosis, even when quiescent, harm has been done by sunlight exposures, especially with too intense and prolonged irradiations. Solar heat alone, especially in summer, can prove very exhausting. An observing patient will note fatigue, exhaustion, irritability or even overstimulation after these solar baths. With this reaction, sunlight should be discontinued. If symptoms are due to overdosage only, exposures may be resumed after an interval, shorter or less intense exposures being employed. Increase of local symptoms, such as cough and expectoration, and pleurisy, or of systemic symptoms, such as elevated pulse and temperature, serves as a guide. In these cases it may be advisable to substitute irradiations of diffuse daylight of longer duration, or of low intensity sunlight in the early morning and late afternoon hours.

In an active febrile pulmonary tuberculosis complicated by active intestinal tuberculosis, mercury quartz irradiations have been regularly used by many for the intestinal complication and not infrequently with favorable effect. In such cases the activity and nature of the pathologic changes of the pulmonary disease have been disregarded. The favorable empirical results thus obtained and the poor results obtained when other treatments have been used justify this as an indicated therapy.

For other forms of active extrapulmonary tuberculosis, such as that of bones and joints, or lymph nodes complicating active

pulmonary tuberculosis, light exposures have been often used to advantage, so that the pulmonary disease, if not rapidly progressive, offers no contraindications. However, careful observations, especially in exudative forms of pulmonary disease, will not rarely reveal the development of harmful pulmonary focal reactions due to excessive exposures to ultraviolet. This should deter one from exposing such patients indiscriminately.

Focal reactions have been shown to occur in the lungs, even when direct sunlight is reflected in overdosage on a tuberculous larynx. Some workers observed their occurrence when the limbs alone were irradiated with the mercury quartz and carbon arc lights. In the use of both lamps and sunlight, one often notices on beginning treatment a slight elevation of temperature with mildly increased focal pulmonary symptoms. This reaction has been likened by some observers to a tuberculin reaction. A focal reaction such as has been observed in the lungs, larynx and joints has been obtained in cases in which good pigmentation developed. A latent period always exists before signs of the reaction appear. By the screening of lupus areas from the light and exposing the rest of the body, the diseased tissue has often healed, indicating apparently the transport by the blood of some substance to the focus. However, therapy is preferably carried out by exposing the diseased parts in addition, because the local inflammatory reactions obtained through direct irradiations may be of importance.

Harm due to irradiation of patients with pulmonary tuberculosis results almost always from an indiscriminate use of ultraviolet radiation, with overdosage. It may be manifested with increased local symptoms; namely, increased cough and expectoration, localized pain, blood streaked sputum or hemoptysis and, following these, fever and tachycardia.

Pleural Tuberculosis.—Pleural tuberculosis, dry or serous, especially if it is the initial clinical manifestation, is occasionally aided by ultraviolet therapy. The acute serous form is not to be irradiated. A tuberculous pleurisy with no obvious pulmonary disease usually responds to ordinary rest and hygienic-dietetic treatment; cases not responding after about a month of such treatment may call for irradiations. Pleurisies occurring in the course of obvious pulmonary tuberculosis, as well as pneumothorax cases, offer the same indications as the lung disease. Tuberculous empyemas do not respond. If sinuses are infected, they are rarely helped by local and general ultraviolet applications. Pleural tuberculosis in the Negro, peculiarly enough, has been cited as favorably responsive to ultraviolet radiation.

Laryngeal Tuberculosis.—Laryngeal tuberculosis is practically always secondary to pulmonary tuberculosis, so that the indications for the treatment of the larynx depend on the nature of the disease in the lungs. Here again ultraviolet by itself is not curative but exercises its part only as an adjuvant to the other

mainstays of treatment. General ultraviolet light exposures are made to the body, with at times additional laryngeal local exposures. The acute forms of laryngeal tuberculosis, particularly those with edema, are not indications for ultraviolet therapy. Exposures of ultraviolet radiation are made with the aim of producing a mild focal reaction, the reaction being allowed to subside before the next exposure is made. Those patients in whom mild focal reactions developed through irradiation showed often a greater tendency to heal, but no advantage to be gotten from a local treatment to the larynx is cause enough to compel a patient to leave his bed when his active disease indicates bed rest. Furthermore, general body irradiation in this complication plays a large part. Local ultraviolet therapy has proved useful as a postoperative measure in cauterization cases, and as a sedative measure in cases in which cauterization cannot be done.

Tuberculous lymph nodes may be seen clinically in three different stages; namely, as enlarged nodes which have undergone hyperplasia, as nodes which have proceeded to the stage of caseation and softening, or as softened nodes which have perforated to the exterior through a sinus tract. In the first stage, general body exposures to repeated erythema doses of ultraviolet radiation are not infrequently followed by an inflammatory reaction at the nodes with slight pain, tenderness and swelling. In the majority of cases the inflammation subsides and the lymph node finally heals. Occasionally, nodes in the hyperplastic stage may become caseous under light treatment and at times may have to be treated surgically by excision. In such instances ultraviolet radiation is of great value when used postoperatively in preventing the formation of tuberculous sinuses. In the second stage of caseation, light exposures alone will frequently bring about resolution. When softened lymph nodes reach the stage of fluctuation, aspiration or incision is necessary, and then light is most effective. In the third stage, excellent results are obtained in clearing up sinuses of long standing, but occasionally roentgen exposures may have to be combined with light treatment for complete healing to take place. Local irradiation of the sinus area should be made in addition to general irradiation of the body. In cured cases, exposures have averaged from three to eight months.

General body exposures are usually combined with those to the nodes or sinuses. In addition, repeated aspiration, when possible, is made of any fluctuating node, generally entering with the needle from above. At times incision into a softened node is necessary. If the nodes do not heal with these measures, x-rays are resorted to.

The prognosis will vary frequently, depending on whether the patient has also pulmonary tuberculosis and what the prognosis of the pulmonary disease alone will be.

For nodes not yet broken down, local and general sunlight or artificial light exposure, together with the application of x-rays, is the treatment of choice. In the softening stage of tuberculous adenitis, treatment is first best attempted with sunlight or sunlamps and without x-rays. Aspiration is usually necessary. With sinuses, occasionally the use of radiant heat may help to close them if combined with ultraviolet exposure.

Secondary Ulcerative Intestinal Tuberculosis.— Secondary ulcerative intestinal tuberculosis is the most frequent complication of pulmonary tuberculosis, occurring in from 50 to 80 per cent of the patients who die of pulmonary tuberculosis as revealed by necropsies.

Artificial light and solar therapy, as well as a rich vitamin diet, should be used in most cases, as they frequently relieve the symptoms and bring about recovery. When the desired results are not obtained by radiation therapy, roentgen treatment of the intestinal tract should be carefully given or other additional measures employed.

Excellent results are obtained with the use of artificial sources of radiation, with general exposures either of the mercury arc in quartz or of carbon arc sources. The results depend on factors such as the general status of the patient and the location, extent and nature of the disease in the intestine. Those with far advanced pulmonary and intestinal tuberculosis with little remaining resistance cannot be expected to respond, but intestinal tuberculosis today is healed in many patients, and necropsies have often confirmed this.

It is seen that, with ultraviolet exposures and hygienic treatment, the symptoms referable to the intestinal tract generally vanish during the first few months of irradiation, but the exposures should be continued for at least six months to two years. The loss of symptoms is frequently surprising, abdominal pain and discomfort disappearing, diarrhea and fever subsiding quickly and general improvement taking place. Roentgenologic studies show that the intestinal irritability as visualized by x-ray defect clears up entirely in many instances. It is usually best to continue ultraviolet therapy for many months after an apparent cure has occurred.

Peritoneal Tuberculosis.—In peritoneal tuberculosis, ultraviolet therapy always deserves a trial first. The serous exudative type generally responds to irradiation, both in children and in adults. The dry proliferative form, usually adhesive, is more refractory. When there have been ulcerations and large caseous lymph nodes, as commonly seen in children, the results are most unsatisfactory. When the disease is of long standing, healing is more difficult than when irradiation is begun a short time after onset.

Pain under ultraviolet therapy usually disappears rapidly, especially in children. Large quantities of ascitic fluid may disappear in a few months.

Genitourinary Tuberculosis.—If unilateral renal tuberculosis is diagnosed at the very onset of symptoms and when such symptoms are slight, conservative treatment with ultraviolet radiation has on rare occasions prevented the need of surgical intervention. As a rule, nephrectomy is indicated. For unilateral progressive renal tuberculosis or bilateral disease in which the more involved kidney is removed, ultraviolet radiation is to be advised as a desirable postoperative treatment. It may have a favorable action on the genital organs and the remaining kidney and effectively contribute to the healing of a tuberculous cystitis, whether alone or in association with medical treatment. Ultraviolet therapy exercises a healing action on the stump of the ureter, which so often shows residual ulceration, resulting in a discharging sinus or a persistent cystitis. It has given excellent results, even with chronic gaping wounds, extensive and deep, and even when covered with ulcerations and tuberculous granulations. The edges of the wound are separated and held apart with broad strips of adhesive plaster to allow the ultraviolet rays to penetrate the depths and to prevent formation of a closed pocket, which would favor purulent retention as a result of a premature superficial closure. Such extensive wounds may heal with a linear elastic scar and often are hardly visible in the pigmented skin.

Ultraviolet is particularly indicated in those not infrequent cases of renal tuberculosis complicated by genital tuberculosis in which the seminal vesicles and prostate are involved, thus often obliging postponement of cystoscopy to avoid trauma of the prostate and the risks of general infection. In such cases it is imprudent to consider the kidney disorder as an independent lesion, for it is but one manifestation of tuberculosis affecting the whole genitourinary system. Therefore, before surgical intervention it is advisable to treat the concomitant lesions with a methodical course of ultraviolet radiation to make cystoscopy and nephrectomy procedures of less risk of dissemination.

In bilateral renal tuberculosis, ultraviolet therapy is indicated. It may help render the disease quiescent; its occasional analgesic action on ulcerations of the bladder is particularly welcome. It is in these cases of bilateral tuberculosis that advanced infection implicating the genital tract is so often encountered. While the renal lesions tend to become stationary, there is often a steady regression and improvement of the prostatic and bladder lesions and their clinical symptoms.

Advanced bilateral renal and bladder tuberculosis has rarely responded to any form of therapy, especially when the patient is cachectic. Pain has occasionally been relieved by ultraviolet exposures, but the frequent urination is very resistant. Occasionally removal of the more diseased kidney has temporarily relieved the symptoms. Postoperative sinuses, especially following nephrectomy, have responded in a large number of cases to ultraviolet therapy of all forms.

Circumscribed tuberculous lesions of the urinary bladder have improved under local intravesical exposures of ultraviolet radiations from the low pressure cold mercury discharge.

Bone and Joint Tuberculosis.—In bone and joint tuberculosis, heliotherapy, although not the mainstay of treatment, is always employed in combination with other forms of therapy. Orthopedic measures, rest in the open and light form the basis of conservative therapy. Combined conservative treatment includes orthopedic measures, such as immobilization of joints, traction and careful use of passive and active motion, use of ultraviolet air, tuberculin and diet and judicious application of surgery.

Ultraviolet therapy must be admitted to be a real addition to our resources. It is not to be expected that it will produce new cartilage in place of that which has been utterly destroyed; it does not make the process of fusion less necessary than it has been heretofore, but it can help this develop. It is wrong to expect that its use will bring about regeneration of bone equal to that of a few vertebral bodies when they have been destroyed; but when this has occurred and a gibbous deformity exists, ultraviolet therapy has aided orthopedic treatment in fusing these diseased surfaces, especially when employed together with postural treatment.

Surgical fusions are less commonly performed on children under 12 years of age. If performed on adults or children, the disease must first show some evidence of retrogression; thus surgery is to help nature. Following operation, patients are still treated for from one to two years, and during this period heliotherapy plays an important part.

Both mercury arc in quartz and carbon arc irradiations, employed as general and local exposures for prolonged periods of time, have proved aids in the treatment of bone and joint tuberculosis. The technic of irradiation is the same as that described with other forms of tuberculosis. With early exposures, the joints or bones often respond with increase of the local swelling and pain and, if a sinus is present, increased secretion. These in turn subside. Small joints yield more quickly to treatment than large ones. The knee joint is refractory, and particularly obstinate are old fistulas of the spinal column, pelvis or hip. In many instances treatment should be continued for two or more years.

Other Forms of Tuberculosis.—Ultraviolet ray therapy is indicated in various other forms of tuberculosis. Many manifestations of cutaneous tuberculosis respond well to ultraviolet irradiation. Tuberculous ulcers of the mouth and pharynx, usually secondary to advanced pulmonary or laryngeal tuberculosis or to hematogenous dissemination, are most resistant. Electrocoagulation is a more effective therapy.

Aural and ocular tuberculosis are difficult to affect with ultraviolet, although corneal ulcers and phlyctenular conjunctivitis

have not infrequently healed under local exposures. Roentgen therapy has proved effective with tuberculosis of the cornea and iris, but its dose must be moderate and repeated regularly at intervals of about four weeks. These measures are indicated when tuberculin therapy has failed.

RELATIVE MERITS OF DIFFERENT FORMS OF RADIATION

The following outline is constructed with the realization that as yet the relative merits are not accurately defined and not accepted by all. It is offered merely as a possible working basis.

Sunlight is available in almost every locality at some season of the year. Its intensity is variable, but moving air and low intensity sunlight or diffuse daylight can generally be used. In some places where the extreme cold of winter prevents outdoor exposures for a few months, artificial sources of light should be resorted to.

1. *Uncomplicated Pulmonary Tuberculosis.*—(*a*) Sunlight is to be used only after prolonged trial of routine rest, hygienic-dietetic treatment and perhaps in cases in which surgical treatment has failed to cause satisfactory healing (exudative tuberculosis always excluded). Carefully graduated general body exposures are to be made to sunlight of low intensity or to diffuse daylight, together with air baths in the earlier morning or later afternoon hours. The so-called pretuberculosis of children, as well as chronic pleurisies, are all forms in which sunlight can be the treatment of choice.

(*b*) Artificial lights (mercury arc in quartz and carbon arc) deserve a trial only after routine therapy has failed, but one should not expect promising results except in isolated instances. They may occasionally help as an adjuvant. Progressive cases with fever and exudative tuberculosis are excluded. Pleurisies and the "pretuberculosis" of children can be favorably influenced.

2. *Active Extrapulmonary Tuberculosis Without Active Pulmonary Tuberculosis.*—Tuberculosis of the skin, lymph nodes, bones, joints, genitourinary tract, peritoneum, intestine: By this is meant that the signs and symptoms of active or progressive disease are due, not to the pulmonary tuberculosis, but to the extrapulmonary focus. Signs of active disease include both local and constitutional signs.

(*a*) Sunlight is the treatment of choice for bones and joints, lymph nodes and genitourinary tract, especially in the highlands. Graduated exposures of the body are to be made to sunlight, together with the use of rest and hygiene and whatever surgical and orthopedic measures may be necessary. Results are excellent if sunlight is employed over prolonged periods, even in active but not rapidly progressive forms of the disease. Artificial lights should be used, in addition, on cloudy days, especially in cases of cutaneous tuberculosis or discharging sinuses.

(*b*) Artificial lights (mercury arc in quartz and carbon arc) are to be used usually as substitutes for sunlight. However, they may be preferable to sunlight for certain complications, such as superficial, peritoneal and intestinal tuberculosis. Superficial forms include lupus vulgaris and scrofuloderma, keratitis and phlyctenular conjunctivitis. General exposures are always made with additional local exposures over the area of disease.

3. *Active Extrapulmonary Tuberculosis with Active Pulmonary Tuberculosis Accompanied by Fever.*—Both pulmonary and extrapulmonary tuberculosis show subjective evidence of active or progressive disease.

(*a*) Sunlight is the treatment of choice in tuberculosis of the bones and joints and in genitourinary tuberculosis, sunlight of low intensity in the early morning and late afternoon hours being used. The solar and air exposures should be given very gradually.

(*b*) Artificial lights (mercury arc in quartz and carbon arc): The mercury quartz light is often preferred when pulmonary disease is exudative and febrile, because of its great deficiency in heat rays. Better results are then had in tuberculosis of the intestine, peritoneum, epididymis and lymph nodes. It is advisable to alternate mercury quartz irradiations with exposure to the outside air and diffuse daylight.

(*c*) With an acute progressive tuberculous laryngitis, ultraviolet irradiations applied locally are inadvisable until the acuteness has subsided; but, if other measures have failed, ultraviolet irradiations may be tried as a final treatment, if only for their possible analgesic effect. Combinations of local irradiations of ultraviolet and general body exposures are always employed, if possible, according to the indications mentioned.

Benefits are undoubtedly obtained by patients suffering from tuberculosis of the bones, articulations, peritoneum, intestine, lymph nodes and larynx when the entire body is exposed to carefully graded doses of natural sunlight or to radiation emitted by certain artificial sources of light rays. The beneficial results of such irradiation are due not only to ultraviolet rays. The visible and infra-red rays, as well as the conditions of the atmosphere, play a certain part in the therapeutic effect.

In tuberculosis of the skin, lupus vulgaris alone can be said to respond satisfactorily to ultraviolet irradiation. Scrofuloderma and erythema induratum react favorably at times to general and local exposure, although not as constantly.

In tuberculosis of the bones and articulations, it is generally agreed that suitable graded exposure to natural sunlight is most effective in aiding the healing accomplished by orthopedic and other measures. Exposure to artificial sources of radiation is valuable here as a second choice.

Pulmonary tuberculosis, per se, is not an indication for ultraviolet therapy; stationary pleural tuberculosis has often been helped by this measure.

Genitourinary tuberculosis deserves a trial of such treatment in combination with other measures. Local exposure to ultraviolet rays of circumscribed tuberculous lesions of the urinary bladder has been shown to yield favorable results, but the method requires special applicating devices and, above all, skilful treatment of the bladder lesion.

Ocular tuberculosis and aural tuberculosis respond infrequently to light. Oral tuberculosis is most resistant.

Fistulas are often resistant to such treatment. Postoperative sinuses, in contrast, are most responsive.

Intestinal, peritoneal and lymph node tuberculosis especially indicate ultraviolet therapy and often are rapidly responsive.

In tuberculosis, overdosage has produced harmful focal reactions. Here light may set up a focal reaction similar to that of tuberculin.

The erythemic reaction is an accurate indicator of skin tolerance.

Hence a preliminary exposure of a small area to gage the minimal perceptible erythema will avoid undue burns.

SURGICAL VERSUS CONSERVATIVE TREATMENT OF BONE AND JOINT TUBERCULOSIS

With any form of tuberculosis, ultraviolet is to be used merely as an adjuvant and should be combined with all other indicated forms of therapy. The mainstays of treatment, such as rest, proper dietary, and hygienic outdoor life, still remain.

With bone and joint tuberculosis, orthopedic measures combined with light still play the major role. Indications for surgical intervention may depend on many factors: economic and social conditions, the age of the patient, the joints involved, their number and the stage and extent of the disease, involvement of other organs such as the lungs and kidneys, and complicating abscesses or sinuses. Joint tuberculosis is still a local manifestation of a constitutional disease. Surgical measures are therefore in turn to be recognized as adjuvant procedures to be followed by prolonged conservative therapy. Intervention by surgical fusion is always to be seriously considered in the presence of advanced joint destruction. Restoration of function may occur in the synovial form of joint tuberculosis, even in the presence of large effusions; but complete functional return of motion in a joint is doubtful when the bony parts have been destroyed to a considerable degree.

INDOLENT WOUNDS [7]

In certain cases of indolent ulcers and wounds, occasional erythema doses of ultraviolet radiation or daily treatment with graduated doses of solar radiation or artificial ultraviolet rays seem to be helpful. Some indolent ulcers and wounds appear to respond rapidly and favorably to both solar and artificial

7. MacKee and Cipollaro: Ultraviolet Therapy in Dermatology, Handbook of Physical Therapy, ed. 3, pp. 333-358.

ultraviolet radiation. On the other hand, ulcers occurring in Raynaud's disease or in thromboangiitis obliterans and also old chronic varicose ulcers do not respond to ultraviolet radiation.

ERYSIPELAS [7]

Good results have been obtained in erysipelas with both x-rays and ultraviolet rays. Recently many reports have appeared in the literature which show that ultraviolet radiation is a safe and successful method for the treatment of erysipelas, especially in the very young and the old. Many times the erythema dose (eight to twenty) of ultraviolet rays from a quartz mercury arc generator is applied at one sitting to the diseased area including an inch or two of the normal surrounding skin. The treatment is repeated a second or a third time and, if necessary, a fourth or fifth time on successive days. Since erysipelas responds so well in all ages to the sulfonamides, ultraviolet radiation is being used less frequently. The sulfonamides are photosensitizing drugs. Therefore they should not be used in conjunction with ultraviolet rays.

BLOOD [1]

While irradiation with ultraviolet may have some effect on secondary anemia, this effect is limited and not specific and far less efficient than dietetic and drug treatment.

Intense ultraviolet radiation may result in abnormal white blood cell counts. There is no unequivocal evidence that ultraviolet radiation increases resistance to specific or general infection, although a relationship between sunlight and the general course and character of disease, growth and nutrition has been demonstrated.

BLOOD PRESSURE [1]

From a clinical standpoint the claim that ultraviolet rays reduce blood pressure has not been sufficiently established by the majority of those who have had long experience with natural or artificial heliotherapy to command acceptance. Most investigators feel that, while exposure of the entire body to ultraviolet rays may produce some reduction in blood pressure in certain individuals, this reduction is too light and inconstant to be of clinical value. The lowered blood pressure of persons living in the tropics is the result of the action of a number of characteristics, racial, mode of life, meteorological conditions and their changes, and cannot be correlated with the quantity and quality of radiation.

DERMATOSES [7]

It appears to be the general impression in the medical profession and among lay persons that ultraviolet irradiation is of great value in dermatology. However, most of the therapeutic claims have not been corroborated and may be disregarded. There is sufficient evidence to justify the belief that ultraviolet radiation is a valuable remedy for erysipelas and for certain types of cutaneous and subcutaneous tuberculosis. It is reasonably well established that ultraviolet radiation is at times useful

either alone or as an adjuvant for the treatment of acne vulgaris, adenoma sebaceum, pityriasis rosea, parapsoriasis, psoriasis, telangiectasia, indolent ulcers and wounds. While there is some difference of opinion among dermatologists, the majority, while admitting occasional good results that appear to be due to the radiation, do not consider it an important agent in the management of other disorders.

Some physicians believe that ultraviolet radiation improves the color and texture of the complexion. Such statements are not in agreement with the consensus of dermatologic opinion.

Diseases Due Partly or Wholly to Pyogenic Organisms.—Acne Vulgaris: At least 60 per cent of the patients can be cured with conventional dermatologic therapy in from a few months to a year without recourse to ultraviolet therapy. Such treatment embraces the proper choice of topical applications, adequate instruction and advice, attention to hygiene and diet, and attention to various possible internal disturbances.

Erythema or flushing doses of artificial ultraviolet radiation or solar radiation once or twice a week, or daily if toleration is high, will very often cause the eruption to improve or disappear, but unfortunately recurrence is the rule. Rapid temporary improvement in selected cases is obtained often by producing an acute reaction followed by desquamation. Most dermatologists agree that the radiation is a useful adjuvant when treating recalcitrant cases. In such instances it supports topical remedies and other conventional measures. It may be combined with x-rays, but, if so, it is advisable to avoid erythema.

Acne vulgaris is divided into a number of clinical varieties. The intelligent management of the disease requires a clinical knowledge of the various types because the therapeutic indications differ somewhat with the type. Acne indurata is the common type. It is encountered mostly in late adolescent and early adult life and is chronic in course and appearance. In addition to comedones, patulous follicular orifices and scars there are numerous large, deep seated pustules and perhaps occasional indolent cystlike lesions. The skin is likely to be excessively oily. This type usually tolerates and responds well to vigorous treatment.

The more acute types—acne pustulosa and acne erythematosa—are more likely to be associated with detectable and correctable systemic disturbances. It is advisable to begin treatment with soothing topical remedies before resorting to physical therapy.

Comedo and acne papulosa are seen most often at puberty. The lesions consist of blackheads and papules, and there may be also some pustules and an oily skin. At times these types disappear spontaneously or yield quickly to stimulating topical remedies. Not infrequently, however, it is impossible to cure the puberty cases permanently until the patient is somewhat older. It is possible, as a rule, to control the disorder through

this period with suitable topical remedies or with ultraviolet radiation or both. It is important to do so; otherwise acne indurata, oily seborrhea, scars and a coarse skin are apt to develop.

Although ultraviolet radiation has been blamed for superfluous hair in cases of acne vulgaris, it is generally agreed that this agent cannot make hair grow on glabrous skin. Hypertrichosis in association with acne vulgaris has been noted in the absence of local treatment of any kind. However, when girls and women have a tendency to grow hair on the face it is theoretically possible that the frequent application of any remedy producing hyperemia might encourage the growth.

Rosacea and Rhinophyma: Rosacea can almost always be cured by giving adequate attention to the internal causes combined with suitable topical remedies. Irradiation is of little if any value. Ultraviolet radiation is usually not well borne, although it may be of service in an occasional selected case. So far as concerns local treatment, the best results in cases of hypertrophic rosacea and rhinophyma are obtained with multiple scarification, surgical diathermy and scalpel surgery.

Acne Varioliformis: Ultraviolet radiation is of doubtful value.

Sycosis Vulgaris: Ultraviolet radiation appears to have very little effect on the disease. Under the heading of sycosis may be included chronic pustular folliculitis of the bearded region of male adults, the eyebrows, the scalp and the pubic region. In such cases general body irradiation with solar or artificial ultraviolet radiation may be tried, but there is no real evidence that such treatment is of value.

Furunculosis and Carbunculosis: Many physicians believe that an erythemal or a blistering dose of ultraviolet radiation preferably with a water cooled lamp with compression, when applied to a boil in the very early stage of evolution, will either abort the lesion or greatly modify further development. In the hands of most dermatologists this procedure has been uncertain and disappointing. Recurrent boils indicate some constitutional fault —organic, functional or immunologic—which must be corrected if possible. In such instances it is possible that a long course of general body irradiation, using either the sun or an artificial source of light, might prove beneficial. While the general impression is that such treatment is helpful, there is no conclusive evidence that this is so.

Miscellaneous Pyogenic Disorders: Ultraviolet ray treatment or heliotherapy may be of service in cases of acne conglobata (acne cachecticorum) but the result is usually disappointing. Good results have been reported with ultraviolet radiation in cases of perifolliculitis capitis abscendens et suffodiens, but the evidence is insufficient for an evaluation.

Diseases Due to Fungi.—Many of the fungous dermatoses—blastomycosis, actinomycosis, onychomycosis—have been treated with ultraviolet radiation with poor results. Perlèche, a disease

of the buccal commissures, may be due to bacteria, fungi or to a deficiency of nicotinic acid or riboflavin; ultraviolet radiation has not proved efficacious in this disease. Many eruptions due directly or indirectly to fungi and known as dermatophytosis and dermatophytid are discussed under the heading of eczema.

Eczema: It no longer suffices to say that a certain agent is of value in the treatment of eczema. Today the unqualified term eczema signifies inflammation of the skin (dermatitis) having certain characteristics that are not so frequently encountered in other eruptions. Each of the number of clinical types of eczema has a somewhat different cause and exhibits fairly definite characteristics. While the therapeutic indications are somewhat different for the various types, each clinical variety has certain features common to all.

Eczema venenatum (dermatitis venenata) is caused by external contact with a substance to which the patient has become sensitized. Well known examples are rhus dermatitis, dye dermatitis and trade eczema. Naturally the logical procedure is to ascertain and remove the cause. Ultraviolet radiation is not indicated in this type.

Dermatophytosis is a convenient term coined by Highman to indicate eczema caused by fungi, of which there are several types. To general practitioners and to the public these conditions are known as ringworm, or "athletes" foot.

The keratotic type occurs mostly on the palms and soles and consists, as the name implies, of a thickened horny layer. The interdigital and vesicular varieties are the common types of dermatophytosis. Ultraviolet radiation has been advocated, but the results do not warrant its recommendation.

Infectious eczematoid dermatitis is a more or less generalized eczema that develops secondary to a discharging sinus, ulcer or wound. Ultraviolet radiation is also ineffective in this type.

Neurodermatitis occurs in two forms—circumscribed and disseminate. The circumscribed type (lichen chronicus circumscriptus), seen mostly in adults, resembles patches of chronic lichen planus and shows a predilection for the flexures—the sides of the neck, the cubital and popliteal spaces, and flexor surfaces of the thighs: and for certain extensor surfaces—the elbows and knees—where it may exhibit a strong resemblance to psoriasis, and the back of the neck in women (eczema nuchae). The Fox-Fordyce disease of the axillas and pubic region is probably a rare type of circumscribed neurodermatitis. Patches of circumscribed neurodermatitis range in size from a dime (18 mm.) to an adult palm. A full erythema dose of ultraviolet radiation may be followed by improvement, but the results are uncertain.

The disseminate type of neurodermatitis, when severe, is one of the most recalcitrant and distressing of the dermatoses. It occurs for the most part in patients who give a personal or family history of allergic disorders—urticaria, hay fever, asthma —and the patient is often sensitized to a large number of

substances—food proteins, epithelial products (hair, dander, feathers), pollens and bacterial proteins. The neurogenic factor is prominent, and there may be endocrine dysfunction. The disease is common in infants, children and adolescents, less common in young adults and uncommon in older persons. There are acute exacerbations and remissions, both of which may be of short or long duration. Itching is likely to be almost intolerable.

There is a difference of opinion regarding the efficacy of ultraviolet radiation (general body irradiation) in neurodermatitis. Certainly many patients improve when they are able to indulge in heliotherapy, but it has been impossible thus far to determine whether the improvement is due to a combination of environmental factors (rest, relaxation, contentment, salt water bathing, effect of moving air on the naked skin, change of climate, escape from causative proteins) or to ultraviolet radiation.

Only occasional good results are obtained with artificial ultraviolet radiation, and in these instances improvement might have been due to other factors. Many patients have a low tolerance for radiant heat and appear to be made worse with small doses of ultraviolet radiation. Amounts sufficient for erythema are likely to precipitate an exacerbation.

Eczema seborrheicum (dermatitis seborrheica) presumably a bacterial, rather polymorphous, type of eczema in its most simple form may consist of dandruff, a few scaly patches on the face and ears, or excessive oiliness of the face and scalp. The more severe eruptions consist of exudative and crusted patches on the head, scaly patches and patches of follicular papules on the trunk, and erythematous scaly patches under pendulous breasts and in the pubic and crural regions. It is often difficult to differentiate between seborrhea, dermatophytosis and psoriasis. Occasionally ultraviolet radiation appears to give good results, especially erythema doses for chronic dry patches, but in general it may be stated that ultraviolet radiation has not been of much service in the management of this form of eczema.

Eczema hemostaticum (dermatitis hemostatica) generally occurs on the legs of elderly persons and is due primarily to poor local circulation caused by varicose veins, cardiovascular disturbances, renal inefficiency, tight circular garters and so on. Additional causes are scratching and infection with pyogenic organisms. The principal treatment consists in support for the circulation (elastic stockings) and the correction of constitutional disturbances. Ultraviolet radiation appears to be of benefit for the indolent ulcers that so often complicate the disorder and it may be of service when the skin is considerably thickened. On the whole, however, ultraviolet radiation is not efficacious for this type of eczema.

Intertrigo is an erythema occurring in locations where the parts are in contact (axillas, crural region) and is due to friction, heat and unhygienic conditions. Dermatitis, with edema,

exudation and crusting, may develop (eczema intertrigo). Differentiation must be made from dermatophytosis. Ultraviolet rays have been used for recurrent eruption with questionable results.

The term infantile eczema signifies no more than eczema occurring in an infant. Usually such eczema is one of the enumerated types or a combination of two types. So far as concerns ultraviolet, there are no special indications other than those found throughout the section dealing with eczema.

Many dermatologists claim that ultraviolet rays are useful for many varieties of eczema and in selected cases this is possibly true, but in general terms American dermatologists agree that ultraviolet radiation is not of much value in this disease. It is not indicated in acute eczema. General body irradiation may be of some value in selected cases of chronic eczema. At times, any agent that will evoke hyperemia in a patch of chronic squamous eczema will hasten recovery. Ultraviolet radiation may be used for this purpose; however, judgment is required or the condition is apt to get worse instead of better. Such treatment may be successful, but the physician is taking a risk.

Psoriasis, Parapsoriasis, Dermatitis Exfoliativa, Lichen Planus: In psoriasis, ultraviolet radiation in amounts sufficient to cause erythema, applied to the individual lesions about once a week, will at times promote resolution. Such treatment, however, is not particularly efficacious and, if the erythema involves the normal skin, the lesion may spread over the entire area of erythema.

Daily heliotherapy to the entire body, irrespective of the location of the eruption, or daily general body irradiation with artificially produced ultraviolet rays, is thought by many dermatologists to be of value. It is advisable to avoid erythema because the too vigorous treatment of psoriasis, especially the more acute types, may favor the development of dermatitis exfoliativa. In fact, radiation is contraindicated in the acute types. If general body irradiation is proved to be of real value, it would seem to be a particularly favorable treatment for children. Goeckerman and O'Leary's coal tar technic appears to have given better results in psoriasis than the use of ultraviolet radiation alone. This consists in applying a 3 per cent crude coal tar ointment at night. The next morning the ointment is wiped off. This is followed by irradiation of the entire body, after which a bath may be taken. When possible, the treatment is given daily. The most that can be hoped for in psoriasis is control of the disease; it cannot be cured.

Remissions in parapsoriasis, an incurable disease, have been reported with erythema doses of ultraviolet radiation. There are several types of the disease, only two of which have at the present writing responded temporarily to the treatment—the papular and the plaque or patch types.

Ultraviolet radiation has not been found useful in dermatitis exfoliativa.

Pruritus; Prurigo.—Ultraviolet radiation is recommended by some for the various types of essential pruritus—pruritus ani, pruritus vulvae, so-called senile pruritus—but the majority of dermatologists have not been favorably impressed with the results. Erythema doses may increase the pruritus.

Ultraviolet rays have been advocated for the relief of pain associated with diseases such as zoster. They appear to be of little service for this purpose.

Prurigo nodularis does not yield well to ultraviolet rays, although a few apparently satisfactory reports have been published. The same statement applies to prurigo mitis and prurigo ferox.

Diseases of the Appendages.—In hyperhidrosis, ultraviolet radiation is not usually effective.

Although pompholyx is thought by some to be an entity, the majority appear to believe that it is a variety of dermatophytosis or dermatophytid. Often it is but a transient eruption. In any event, ultraviolet ray treatment has proved disappointing.

Alopecia may be divided into alopecia areata and alopecia prematura. The first consists of circumscribed bald patches on the scalp or face. In some instances the entire scalp, the face and even the trunk and extremities may be involved—alopecia totalis. The cause is not known. It may be endocrinologic or neurogenic.

Alopecia prematura may be divided into cases caused by seborrhea capitis (alopecia seborrheica) caused by systemic disturbances such as acute febrile diseases, chronic systemic disorders, neurogenic factors (alopecia systemica) and those cases for which no cause can be found except a family history of early baldness (alopecia idiopathica or hereditaria).

Although ultraviolet radiation has been used extensively by a large number of dermatologists and others in the treatment of all types of alopecia, there is now fairly general agreement that ultraviolet radiation is in no sense a specific, that it is not a "hair grower." In amounts insufficient to produce erythema it appears to be useless. Quantities sufficient for vigorous hyperemia probably do no more than hyperemia evoked by any agent—phenol, for instance. If this is conceded, ultraviolet radiation may be considered to be a useful adjuvant for the treatment of alopecia areata and the several types of alopecia prematura. It is not improbable that recovery in many cases of alopecia areata is spontaneous. The prognosis in alopecia idiopathica is unfavorable. If proper attention is given to the constitutional disturbances in cases of alopecia systemica, the prognosis is excellent. Early cases of alopecia seborrheica respond favorably to topical applications. Finally, it may be stated that all types of alopecia can be handled as successfully without as with ultraviolet radiation.

Tuberculosis of the Skin and Allied Conditions.—Lupus Vulgaris: Lupus vulgaris is definitely benefited by treatment with ultraviolet rays. A great deal of time and patience is required but the results often reward the effort. A combination of generalized and localized ultraviolet radiation yields the best results in the treatment of this condition. Excellent results by careful exposure of the entire body to sunlight have been obtained. Concentrated carbon arc light therapy by the Finsen method gives the best results, as far as concerns regional treatment. Beneficial results also may be obtained with the water cooled quartz arc lamp, especially when it is possible to dehematize the area by pressure with the quartz frontpiece on the lamp. Dehematization may be obtained also with local injections of epinephrine, but the results are not as good as with compression. The dose must be heavy—several or many times the erythema dose at each sitting. Of course the reaction is severe, and the treatment is not repeated until the reaction has disappeared.

Such large doses require from five to twenty minutes. Since only a small area (a square inch or two) is covered in one exposure, a great deal of time is required for the treatment of extensive eruptions.

There is enough reliable clinical evidence available to give substantial support to the belief that daily general body irradiation with an air cooled quartz mercury arc lamp is of real value. Solar radiation of the entire body probably gives better results. Such treatments may have to be continued for several or many months. Ultraviolet therapy may be combined with general systemic treatment including bed rest and with such treatment as tuberculin injections, high vitamin well balanced adequate diet and, if proper precautions are taken, with roentgen treatment. It is not, of course, possible to cure all cases. A number of complications, such as tuberculous lymphangitis and visceral tuberculosis, may prevent the patient from reacting favorably to any treatment.

Lupus Miliaris Disseminatus: As far as is known, this type of true cutaneous tuberculosis has not been treated with ultraviolet rays. The eruption is likely to disappear spontaneously in a few months.

Lupus Erythematosus: Apparently radiation is not of much value in this condition. At times, discoid patches may be benefited with erythema doses of ultraviolet rays applied directly to the lesions. However, these patches may be made worse by such treatment. General body irradiation was formerly used, but there is sufficient evidence to indicate that erythema is followed at times by the precipitation of disseminate lupus erythematosus. Radiation was used more in former years than at present. General ultraviolet radiation in cases of lupus erythematosus not only yields poor results but may cause dangerous sequelae. Therapy with gold salts and with bismuth has

given such satisfactory results that other therapeutic methods are used mostly as adjuvants in selected cases.

Tuberculosis Orificialis: Good results may be obtained with ultraviolet irradiation in cases of tuberculosis of the orificial mucous membranes. However, when the desired result is not obtained in a reasonable time, other local methods, such as x-rays, grenz rays and the electric cautery or surgical diathermy, should be seriously considered. Most orificial tuberculosis is secondary to involvement of the viscera, and general medical attention is required.

Tuberculosis Verrucosa Cutis (warty tuberculosis of the skin, verruca necrogenica, anatomic tubercle): Ultraviolet rays have not been found very useful in this disease.

Scrofuloderma: Satisfactory results have been obtained in many cases of scrofuloderma with and without tuberculous adenitis. The best treatment appears to be adequate attention to the general health, a suitable diet, tuberculin injections and daily general body irradiation with either solar radiation or artificial ultraviolet radiation. Locally applied ultraviolet radiation alone fails. Stubborn cases in which there is an underlying suppurating tuberculous focus (glands, bones) may require surgical intervention.

Erythema Induratum (Bazin's disease): The local application of ultraviolet radiation is of questionable service. These patients should be handled from a general medical standpoint—rest, light exercise, diet and general body irradiation (solar or artificial ultraviolet radiation).

Sarcoid: Thus far, ultraviolet radiation has not been shown to be of real service in the management of the two types of sarcoid (Boeck type and Darier-Roussy type). Statements made under the headings of Bazin's disease and sarcoid apply also to that apparent variant of these conditions, periphlebitis nodularis necroticans.

Granuloma Annulare: Ultraviolet rays appear to be of little if any value in this disease.

Tuberculid: Papulonecrotic tuberculids exhibit eruptions which are usually widespread and bilateral and are characterized by remissions and exacerbations. In some cases generalized ultraviolet radiations seem to shorten the course of the disease and in others radiation seems to have no effect. The treatment of lupus pernio with ultraviolet radiation is ineffectual.

Nevi.—Nevus Araneus: Spider nevi can be eradicated with blistering doses of ultraviolet radiation, but electrolysis is a much better method.

Nevus Flammeus: Port wine marks are exceedingly difficult to eradicate. Blistering doses of ultraviolet radiation, administered by the water cooled quartz mercury arc lamp with compression, may occasionally improve very faint nevi of this type and may reduce the color of more pronounced lesions.

Other types of vascular nevi and the pigmented nevi do not respond favorably to ultraviolet ray treatment.

Adenoma Sebaceum: Good results with blistering doses of ultraviolet radiation have been obtained in this disorder usually with the water cooled quartz mercury arc lamp with compression.

Telangiectasia: This condition, when occurring as a sequel to roentgen or radium treatment, can be improved with ultraviolet radiation. Either the water cooled or air cooled lamp at a distance may produce satisfactory results. As pointed out by Hazen and by C. Guy Lane, x-ray and radium skin has a low toleration for such radiation. Therefore, the initial dose should be small. As a rule, it requires from one to several erythema doses or even blistering doses to destroy the capillaries. It is best not to treat with strong doses of ultraviolet rays most cases of radiodermatitis as too vigorous treatment may in some severe cases cause the tissue to ulcerate. It is difficult to obtain the correct amount of vascular destruction. When the treatment is too vigorous, the treated area is likely to be too white and also the atrophy caused by the x-rays or radium becomes more visible.

Miscellaneous Cutaneous Disorders.—Dermatitis Herpetiformis and Pemphigus: There have been numerous reports of good results with general body irradiation with ultraviolet rays in cases of dermatitis herpetiformis and chronic pemphigus. However, others are not convinced that the radiation is of value for the purpose. Evaluation is difficult because these diseases are characterized by exacerbation and remission.

Scleroderma: Ultraviolet radiation has been advocated for scleroderma, both local applications and general body irradiation being used. The results have been very discouraging.

Milia: Ultraviolet rays have been tried in a few cases and have not proved beneficial.

Pityriasis Rosea: Ultraviolet radiation has been found useful for shortening the course of pityriasis rosea. One dose, sufficient to cause erythema and exfoliation, may suffice to clear up the eruption. Apparently it is the exfoliation that effects the cure. It is advisable to avoid too severe an erythema, especially for the first dose in severe cases. It is customary to give a sub-erythema dose at the first sitting to determine toleration. A few days later a full erythema dose may be given. The natural course of this self-limited disease is from one to three months. Subjective symptoms usually are mild or absent, and the eruption seldom attacks the face or other exposed parts. For these reasons most patients prefer to avoid the discomfort that is likely to be associated with a widespread sunburn. In some cases of pityriasis rosea the eruption is severe; inflammatory and subjective symptoms are annoying, and it is doubtful whether ultraviolet radiation is indicated.

Leukoderma: The literature contains many reports of good results in the treatment of this disease with local applications of erythema doses of ultraviolet rays with and without general body irradiation. The modern dermatologic consensus is that the method is almost, if not completely, useless. As a rule, such treatment is likely to make the areas more conspicuous because the white areas do not tan while the surrounding areas become very dark. Recently, occasional satisfactory results have been obtained by painting the white areas with oil of bergamot and applying ultraviolet radiation in quantities sufficient to evoke erythema.

UNDESIRABLE RESULTS IN DERMATOSES

Many of the inflammations, especially when acute or subacute (eczema, psoriasis and the like), may be made more acute or to spread or change character by too vigorous treatment with ultraviolet radiation. For instance, a patch of subacute eczema of any type may change to exudative eczema and may then become more or less generalized (infectious eczematoid dermatitis). Although a patch of chronic psoriasis will usually tolerate and may even be benefited by an erythema dose, on the other hand the patch may spread over the area of erythema if the normal skin is not protected. When treating individual lesions of any dermatosis, it is advisable to protect the surrounding normal skin. Generalized psoriasis, especially if it is of the more acute or inflammatory type, if treated too vigorously, may change to universal psoriasis or dermatitis exfoliativa. The same phenomenon is observed at times in cases of eczema. It is admitted that vigorous treatment may at times make large patches of psoriasis and eczema disappear, but such treatment is risky.

Large doses of solar radiation and of artificially produced ultraviolet radiation may precipitate attacks of herpes simplex and lupus erythematosus. Erythema and even suberythema doses of ultraviolet radiation applied to the normal skin of patients suffering from lupus erythematosus may cause the development of the disseminated type of the disease. In certain individuals infra-red rays or any form of heat applied for a considerable period will provoke a mottle erythema and pigmentation known as erythema ab igne.

The so-called sailors' skin or farmers' skin is a presenile condition of the skin of the exposed parts occurring in persons who are exposed to solar radiation more or less constantly for many years. The skin is wrinkled and dry, and keratoses of the senile type are likely to develop. These in turn not infrequently change to cancer. Farmers' skin may consist only of permanent freckles, most commonly seen on the shoulders, the upper part of the back, the chest and the backs of the hands. These freckles are not especially dangerous, but occasionally one may change to a keratosis and later to cancer. Farmers' skin in many ways resembles the so-called x-ray or radium

skin (x-ray or radium sequelae). It also resembles xeroderma pigmentosum, a condition due to exceedingly low cutaneous tolerance to light.

It becomes manifest on the exposed parts of such patients early in life, being most pronounced on the face. The eyes are congested, the skin is dry and atrophic, ectropion develops and there are innumerable freckles of the permanent type and keratoses of the senile type. Curiously, many of these keratoses change to basal cell epitheliomas rather than to epitheliomas of the prickle cell variety. Patients who have a low cutaneous toleration to light not only should avoid direct sunlight and artificially produced ultraviolet radiation but should avoid strong daylight, because diffused sunlight and reflected light from snow, water and sand contain large amounts of ultraviolet radiation. If such patients find it necessary at times to be exposed to strong solar light, the face and hands should be protected with veils, walnut stain, an alcoholic solution of glycerite of tannin, or cream containing dark substances, such as burnt sugar or ichthammol. A preparation which has been found effective to protect the skin against the effects of ultraviolet radiation is the following:

℞	Phenyl salicylate	1 Gm.	gr. v
	Tannic acid	5 Gm.	ʒ ss
	Wool fat		
	Petrolatum flavosum..........aa q. s. ad	100 Gm.	℥ i

For very mild cases, a coating of yellow petrolatum followed perhaps by a dark colored powder may provide sufficient protection. The fad of exposing bodies of children to solar radiation and artificially produced ultraviolet radiation daily and indefinitely without medical supervision may eventually give rise to farmers' skin in a small percentage of children who happen to be idiosyncratic.

Hydroa vacciniforme is a rare bullous disease, mostly of children, limited to the exposed parts and occurring during the spring, summer and fall. The etiology is supposed to be associated with the effect of light on the skin of a susceptible person. Hematoporphyrin has been found in the urine of these patients, and it is thought that this and other substances may have something to do with sensitization to light. In the same category may be placed pellagra, and summer prurigo melanosis, simulating chloasma and argyria, has been reported following sunburn.

Certain substances when injected into the body or painted on the skin appear to cause sensitization to light. There is one instance in the literature (Meyer-Betz) in which hematoporphyrin was injected. Exposure to the light caused edema of the hands and face. Eosin, when painted on the skin combined with exposure to light, may result in severe dermatitis. Oil of bergamot and perfumes on the skin may be followed by derma-

titis and pigmentation on even mild exposure to sunlight or ultraviolet radiation (berlock dermatitis). Attempts in this way have been made to modify or cure leukoderma with occasional success.

Skin affected with certain diseases, especially with the desquamating fungous diseases such as chromophytosis, when subjected to radiation that causes tanning may assume a peculiar appearance, so much so as to interfere with diagnosis. Chromophytosis is a good example. The patches of eruption are of a yellowish brown, and the surrounding normal skin tans so that its color matches fairly well that of the affected areas. The patches of disease do not tan because the slightly thickened horny layer absorbs the radiation. Exfoliation of this horny layer leaves white patches, which are in sharp contrast to the surrounding tanned skin. Urticaria and certain forms of recurrent acute dermatitis of the face, neck, forearms and hands are at times thought to be due to sensitization to light.

Conjunctivitis and other eye troubles may be caused by excessive exposure to direct sunlight, reflected sunlight and radiation from ultraviolet generators. Ultraviolet rays from the so-called cold quartz lamp are particularly prone to produce conjunctivitis. Depending on the exposure and the susceptibility, the inflammation may be slight or severe, transient or persistent. Arctic explorers and mountaineers occasionally have "snow blindness." In the industrial field, acetylene and arc welders have trouble with their eyes unless they wear goggles.

Ordinary glass will protect the eyes from ultraviolet rays, but, for protection from all ultraviolet wavelengths and visible light, it is preferable to use glass of a dark color—amber, green or black. It is important that the goggles be edged with soft, opaque material that will obstruct the passage of light between the goggles and the skin.

SUNBURN

Ordinary sunburn is known as erythema solare and dermatitis actinica. In this category may, of course, be placed burns caused by ultraviolet radiation from any source. The reaction may consist of no more than a slight erythema—a flush—or definite erythema accompanied by a sensation of heat followed in a few days or a week by itching and exfoliation. If the reaction is more severe there is edema, vesiculation, erosion and perhaps exudation. The subjective symptoms are burning and itching. Depending on the degree of reaction, spontaneous recovery occurs, as a rule, in from a few days to a few weeks. Occasionally recovery is delayed. Erythema and edema have been known to endure for months. Regardless of severity, in the absence of complications sunburn does not produce a scar. When the area burned is extensive, there may be constitutional symptoms consisting of malaise, headache, fever and vomiting. In fact, a more or less severe constitutional reaction may occur

in the absence of a burn when radiation is applied to the entire body. Such a reaction indicates that the dose is too high for the individual.

Mild and moderate local sunburn requires little if any treatment. Ointment of rose water or almond emulsion may allay the sensations of burning and dryness. When such a burn is extensive and especially when accompanied by constitutional symptoms, the patient may have to spend a few days in bed. Whether the burn is local or more or less generalized, the type of topical treatment indicated depends on the cutaneous objective and subjective symptoms. Constant wet dressings of boric acid, sodium bicarbonate, watery extract of witch hazel or diluted solution of aluminum acetate are indicated when there is vesiculation, erosion and exudation, or when the burning sensation is distressing. When the skin is inflamed and dry, applications of the following lotion may be prescribed:

℞ Zinc oxide			
Magnesium carbonate.................aa	8.0 Gm.	ʒ ii
Alcohol	15.0 cc.	f℥ ss
Menthol	0.3 Gm.	gr. iv
Phenol	2.0 cc.	fʒ ss
Lime water, q. s.....................ad	120.0 cc.	f℥ iv

Unscented cold cream containing 1 grain (0.06 Gm.) of menthol and 1 drachm (4 Gm.) of petrolatum or hydrous wool fat to the ounce (30 Gm.) may be used for the same purpose.

Tan and ordinary freckles disappear completely in time, provided light is avoided. Their disappearance can be hastened by the application of lotions and creams that encourage desquamation. Formulas for such remedies are in all textbooks on dermatology.

METABOLISM [8]

The blood sugar of normal men is not influenced to any extent by ultraviolet irradiation. In some persons with diabetes the blood sugar may be temporarily diminished. The decrease is probably due to increased excretion of insulin and may be accompanied by increased storage of glycogen in the heart, liver and muscle.

It is the opinion of most authorities that irradiation of lactating women increases to some extent the quantity and antirachitic potency of the milk.

Irradiation of moderate intensity increases endogenous nitrogen metabolism. Residual nitrogen is usually diminished. The excretion of uric acid is said to increase, giving support to the use of ultraviolet in the treatment of gout. Ultraviolet irradiation may double the fat content of the blood, cholesterol increasing by 30 per cent.

The effect of ultraviolet irradiation on respiration is to make it easier, deeper and less frequent, although total ventilation

8. Laurens, Henry: The Physiologic Effects of Ultraviolet Radiation, J. A. M. A. **111**: 2385 (Dec. 24) 1938.

per minute remains constant. It is generally accepted that basal metabolism is not influenced by ultraviolet irradiation. When an increase in metabolic rate is observed on isolating the nude body it is due preeminently to the cooling effect of the moving air. If the air temperature is high with little or no air movement, the chemical heat regulating mechanism is brought into action and the metabolic rate diminishes.

Ultraviolet irradiation exerts a glycogen storing effect, preventing the lowering of the respiratory quotient after muscular exercise, which lowering is due to glycogen impoverishment.

Practically all attempts to show effects of light on normal growth processes of man and animals have been negative. Animals will grow as well in darkness as in light if the diet is complete.

Ultraviolet has no influence on the activity of the thyroid. The goiter producing power of cabbage is reported to be increased by ultraviolet irradiation.

The antirachitic effect of ultraviolet occurs in the lowermost cells of the horny layer and in the prickle cells of the malpighian layer, while the production of erythema takes place in the basal cells (germinativum) of the malpighian layer and in the corium. The horny, clear and granular layers act as filters. Ergosterol and cholesterol can be activated by ultraviolet rays which pass through the epidermal layer of the skin. Blood in the superficial capillaries absorbs only a small percentage of energy incident on the skin.

The "burn" produced by ultraviolet takes a few hours to appear and the longest wavelength that can produce it is about 3,150 angstroms. The curve representing relative effectiveness of different wavelengths rises to a maximum at 2,967 angstroms, descends to a minimum at 2,800 angstroms, then rises again to a small maximum near 2,500 to 2,450 angstroms and extends to an undetermined shorter wavelength. Blonds are from 40 to 170 per cent more sensitive than brunets, men 20 per cent more sensitive than women. Persons between 20 and 50 are more sensitive than those younger or older. There is an average maximum sensitivity in March-April and in October-November. A person with an unstable nervous system, an overactive thyroid gland, elevated blood pressure or active tuberculosis shows increased sensitivity. The sensitivity increases at the menses—a maximum being reached on the first day of the cycle—and then declines to normal. After the second month of pregnancy the sensitivity definitely increases until the seventh, after which it diminishes somewhat, being still high at term. Increased sensitivity is correlated with thyroid hyperactivity and with an increased number of open capillaries in the skin. An acid diet increases sensitivity. Salves exert a protective action, an acid salve less than an alkaline.

Erythema shows the reactions of the "triple response" and depends on the setting free of H substance. The acidity of the gastric juice increases simultaneously with its beginning.

Pigment formation and therapeutic benefit are independent, coordinate phenomena proceeding simultaneously in the same direction. Pigment formation is dependent on individual factors, race, coloring, constitution and body function. It can be used as an index in treatment. It is also a measure of adaptation, since pigment formation, horny layer thickening and chemical alterations of the skin cell proteins run parallel.

THE EYE

The cornea begins to absorb at 3,600 angstroms and transmits to between 2,950 and 3,000 angstroms, and the crystalline lens transmits to 3,060-4,190 angstroms, according to age. The vitreous transmits wavelengths as short as 2,300 angstroms, with a broad absorption band from 2,500 to 2,800 angstroms. The lens absorbs wavelengths as short as 2,950 angstroms with no ill effects, but shorter wavelengths produce a severe ophthalmia. Sunlight is ordinarily harmless, but when the ultraviolet component is increased by reflection, as from sand, water, ice or snow, it produces "snow blindness." Glowing arcs and metals which emit energy shorter than 2,950 angstroms are injurious and special ultraviolet absorbing glasses should be worn. The damage is usually limited to conjunctivitis and blepharitis, with prickling pain and uncomfortable foreign body sensation. Edema and contraction of the lids and corneal erosion may occur. Long continued exposure to intense ultraviolet may produce functional disturbances, such as color scotomas and constriction of the peripheral field. Amblyopia and central scotoma have been noted in "snow blindness." "Eclipse blindness" is due to intense local action of infra-red rays.

It is still a question as to whether intense ultraviolet produces lenticular cataract. Many incline to the view that glass workers' cataract is due to the intense infra-red rays which interfere with the nutritional functions of the ciliary body. It is probable that the higher incidence of cataracts in workers exposed to molten glass and metals is due to increased rate of precipitation of light denatured protein when the lens is heated above body temperature by exposure to large sources of radiant heat and when low concentrations of calcium, or other substances producing a similar effect, are present.

Claims have been made that some persons can see wavelengths as short as 3,130 angstroms. This is due to excitation of the retina by fluorescent (longer) wavelengths. The aphakic eye sees shorter wavelengths than the normal eye.

PHOTODYNAMIC OR OPTICAL SENSITIZATION: PATHOLOGY

It is possible to sensitize living cells, like photographic plates, and thus produce abnormal conditions in which light or luminous rays and longer ultraviolet rays are as active as the shorter ultraviolet. The effective wavelengths are those absorbed by the sensitizer. Sensitization occurs at 4,900-5,800, 3,650-3,130 and 2,500 angstroms. The sensitizers are exogenous, taken in

with the food, and endogenous, arising within the organism. Most sensitizing substances are fluorescent, but fluorescence is not the cause. Ultraviolet effects can occur either in the presence or in the absence of oxygen, but the photodynamic effects occur only in its presence. Among photodynamic sensitizers are erythrosin, rose bengal, rhodamin, anthracene derivatives, acridine dyes, methylene blue, quinine, chlorophyll, hypericin and the porphyrins. Gold salts and chemicals of the sulfonamide group are also sensitizers.

Continued and prolonged exposure to sunlight or to the energy of artificial sources containing much ultraviolet may cause systemic disturbances as well as inflammatory and degenerative changes in the skin. The systemic disturbances are not understood, but deaths of infants following short exposure have been reported and severe reactions in adults.

Photodynamic "triple response," produced by intradermally injecting rose bengal and hematoporphyrin, is similar in appearance to urticaria solare and is produced by the wavelengths absorbed by the particular sensitizer. The response is immediate. It is followed by pigmentation and does not occur in the absence of oxygen. The mechanism of the urticarial response includes a photochemical reaction not definitely affected by temperature and a thermal reaction greatly modified by changes in temperature. The latter is probably due to the action of the H-like substance on the small vessels of the skin. The photosensitizer is a carotenoid pigment.

The relation of ultraviolet to pellagra is difficult to evaluate. The clinical impression that sunlight is harmful to the pellagrin has been confirmed again by Smith and Ruffin, according to whom the seasonal incidence of pellagra is conditioned by the degree of dietary deficiency and the intensity of the solar radiation. Exposure of a susceptible subject, who has been subsisting on a deficient diet, to the sun's rays precipitates the acute manifestations of pellagra. Pellagrous lesions, however, occur in the absence of sunlight and they may heal in the presence of exposure to direct sunlight or to ultraviolet radiation. Spies suggests that pellagra is a systemic condition which in itself is the real cause of pellagrous dermatitis and not exposure to the rays of the sun. Under conditions sunlight may act as an irritant and precipitate cutaneous lesions. But any kind of irritant may predispose an area to localization of the dermatitis, the absence of which, however, indicates little as to the cure of the disease. Porphyrinuria in pellagra has been described.

Repeated irritation by ultraviolet rays can cause chronic lesions, which may be precancerous, such as keratosis senilis and xeroderma pigmentosum. It is an open question as to whether xeroderma pigmentosum and skin cancer are really associated with photodynamic action. Roffo believes that in the carcinogenic production of skin cancer by ultraviolet the photodynamic action of cholesterol plays the most important part.

The photoactivity is due to the emanation of hydrogen peroxide or similar products. Korbler does not believe that the frequency of skin cancer is due solely to exposure to strong sunlight, although it may result in sensitization due to local increase in porphyrin.

The action of radiation is paradoxical in this regard. If the cells of the basal layer of the skin receive an excessive quantity of radiant energy the two protective processes of cornification and pigmentation become abnormally great (hyperkeratosis and hyperpigmentation) and a third degenerative process starts. People lacking in pigment or much exposed to ultraviolet rays show the highest percentage of skin cancer. The developing neoplasm occurs in the place of greatest proliferation, beginning in a wartlike hyperkeratosis, a precancerous change. A cancer develops from a precancerous lesion not only as a result of a continuation of the initial insult but as a result of any continued trauma. Thus ultraviolet rays do not cause cancer in themselves. They produce characteristic cell changes leading to precancerous lesions in the skin. Any irritation, including continuously and excessively applied ultraviolet rays, can cause the precancerous change to become malignant.

PHYSICAL THERAPY IN THE TREATMENT OF FRACTURES

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Widespread mechanization of industry, the increase in the employment of machinery in agriculture and the tremendous growth in the use of the automobile have completely changed the fracture picture in the United States in recent years. This change has been in two respects: (1) There has been a great increase in the number of fractures which occur annually; (2) there has been a marked increase in the number of serious fractures. The increase in the number of fractures is traceable to the greater opportunity for suffering trauma likely to cause fracture; the increase in the number of severe fractures is ascribable to the severe damage which results from the type of violence which machinery inflicts. As a consequence of these factors, the fracture problem today must be considered as having two aspects: a medical aspect which includes the recognition, reduction and immobilization of fractures, and an economic aspect which includes the length of time consumed in recovery, as measured by the period over which the individual is disabled or restricted in activity, and the final result, as measured by permanent residual disability. The effectiveness of fracture treatment, then, cannot be based solely on securing union of the fractured bone or bones, for the rapidity with which the individual is returned to work and the extent to which function is restored must also be taken into consideration. Formerly, treatment of a fracture consisted in applying a splint and leaving it to nature to complete the cure; today, when we are dealing with more serious and more complicated fractures than in the past, a successful end result is dependent not only on adequate immediate treatment of the fracture but also on carefully planned and supervised after-care. Both of these requisites are necessary to meet the demands which the management of fractures make on those who aspire

to treat them and secure end results which will meet the critical judgment of public opinion and compensation commissions.

As this contribution deals with physical therapy as applied to fracture treatment, the immediate treatment of fractures may be briefly dismissed. It should suffice to say that at the present time it is generally conceded that a fracture should be treated as a surgical emergency with reduction under an anesthetic, local or general, carried out at the earliest possible moment and adequate fixation immediately applied. The reasons for this position are quite evident: immediate reduction minimizes local trauma and so cuts down the amount of traumatic exudate and infiltrate which accompanies any injury; it reduces to a minimum the undesirable muscle spasm always present, and it favors the early reestablishment of blood and lymph circulation so important to healing. Following reduction, adequate splinting is necessary to insure continued maintenance of reduction and preservation of the conditions which make for rapid and complete healing.

The proper after-care of a fracture in the main consists of maintaining fixation of the fractured bone or bones until union has occurred, the early restoration of normal circulatory efficiency in the involved region and the building up of muscle tone and power so that normal use may be resumed at the earliest possible moment. Physical therapy, properly and intelligently employed, can be of inestimable service in this period of after-care in hastening recovery, but it is equally true that if physical therapy is used as a part of a routine without a true understanding of its purpose it may be a detriment rather than a help and even actually prolong the period of convalescence by inculcating in the patient a belief that recovery is to be attained by physical therapy alone and without effort on his part.

In order that physical therapy may be intelligently used in the treatment of fractures, it is necessary that its purposes and aims be clearly defined and recognized. Briefly stated, these are (1) promoting the early absorption of hemorrhage and traumatic exudate; (2) relaxation of muscle spasm to relieve pain and discomfort; (3) the reestablishment of normal circulatory conditions in the affected extremity, blood stream and lymphatics, which insures a more rapid and complete

healing of the fracture; (4) building up in the muscles of the extremity that tone and flexibility so necessary to normal use. These effects, as has been emphasized by Clay Ray Murray,[1] are brought about by physical agents acting on the neuromuscular and neurovascular reflex mechanisms and through the stimulation of muscles by physical means or voluntary action.

Broadly speaking, there are four basic forms of physical therapy which may be employed in the treatment of fractures to accomplish the purposes catalogued; they are heat, massage, exercise and muscle stimulation. The first two of these secure their effect by bringing about muscular and vascular relaxation; the third and fourth are of chief importance in promoting venous and lymphatic flow and preparing the muscles to resume their normal active role as soon as use may be safely permitted.

HEAT

Heat as a physical agent may be applied in a number of ways such as by a therapeutic lamp, diathermy, electric pad and as radiant heat by the use of ordinary light bulbs set up in a cradle, and as moist heat in the form of hot packs and whirlpool bath. Heat, to bring about the best results, should be employed at low intensity and over a considerable period. The most important effects secured from heat are analgesia, relaxation of muscles, relief of spasm and vasodilatation, and the longer these effects are maintained within reason the more productive they are. Heat of high intensity which produces a marked erythema cannot be tolerated long and is decidedly less beneficial.

Moist heat in the form of hot packs has several advantages: It is always available as it requires no special apparatus, since the best pack material is that which contains a large per cent of wool, such as a piece of old blanket. Wool yields up heat more slowly than other forms of material. Moist heat in the form of packs is tolerated for longer periods and with less danger of skin reaction than dry heat. Moist heat, clinically at least, seems to have a greater analgesic effect than dry heat and certainly is more efficient in reducing inflammatory exudates.

1. Murray, C. R.: Surg., Gynec. & Obst. **56**: 479 (Feb., No. 2A) 1933.

MASSAGE

Massage has been described as the scientific manipulation of the soft tissues of the living body for therapeutic purposes. Massage is effective when applied by a trained person in a scientific manner; there is a vast difference between the skilled manipulation of a trained physical therapist and the rough and ready methods of the Turkish bath attendant or gymnasium rubber. Properly given, massage stimulates the nerve endings and activates sensory impulses of a wide variety which are important in relaxing muscular and vascular spasm and in relieving pain and discomfort. It also promotes the absorption of hemorrhage and exudate by improving blood and lymphatic circulation in a damaged extremity. The type of massage most useful in the treatment of fractures is light stroking massage; the movement should be slow, even, steady and always in the same direction; that is, lengthwise of the part in the direction of venous circulation. It should be remembered that massage employed to get rid of hemorrhage and exudate and reduce swelling acts by bringing about improved circulatory conditions and does not rub the exudate out of the part by pressure and force. Although all authorities do not agree, it is my opinion that light and very gentle kneading may also be used to advantage in fracture cases; such movements stimulate the intramuscular circulation and improve muscle tone.

MUSCLE STIMULATION

Muscle contractions may be produced by voluntary effort or by electrical stimulation. Voluntary contraction of muscle groups is incomparably superior to any form of artificial stimulation. Unfortunately, however, it is possible to utilize voluntary muscular activity in the treatment of fractures only to a limited extent until union is sufficiently strong. A very useful amount of voluntary contraction can usually safely be permitted and encouraged in most fractures earlier than is generally recognized under proper conditions of immobilization. Such limited voluntary use is made possible by employing fixation (traction or hinged splints) which holds the fractured bone or bones securely but permits the guarded use of adjacent joints, by the use of molded plaster splints instead of circular plaster dressings and

also by having the patient "set" the muscles of the injured extremity a number of times each day; such "setting" of the muscles can be carried out even when the limb is completely encased in a plaster dressing. *The extent to which muscle tone and flexibility can be maintained by carefully supervised daily exercise under proper conditions of fixation is often surprising.*

Muscle stimulation by electrical stimulation, while not as satisfactory as active exercise, is nevertheless a useful therapeutic aid for *maintaining muscle tone.* Pemberton[2] has shown that whereas lactic acid is produced by contraction of muscles following volitional effort it does not arise at least in significant amounts as the result of stimulation of the muscle by faradic current. It is therefore probable that no form of electrical stimulation can be expected to produce the same type of muscle contraction as that which results from voluntary use. To avoid painful contraction some form of sinusoidal current may be used. The Council on Physical Medicine will furnish a design for making a faradic sinusoidal coil. This coil produces a sinusoidal current which will give graduated muscular contraction as described by Bristow and Smart. The value of these contractions is primarily the ensuing increase in circulation in the muscle. When electrical stimulation is utilized to bring about muscle contraction, it should be painless and not cause muscle spasm; for, when pain and spasm are produced, harm rather than good results. Relaxed passive movements are useful in stimulating muscles, provided such movements are carried out with care. To be effective complete relaxation on the part of the patient is essential, and movements are carried only to the limit of toleration. Forcible manipulation which causes painful reaction can be productive of no benefit. Used with judgment relaxed passive movements have an effect on the muscles similar to that secured by sinusoidal current.

Of equal importance with the measures used for applying physical therapy is their use at the proper time. Too often physical therapy is looked on as the final step in fracture treatment, as an agent to be used to restore function to atrophied muscles and stiffened joints which have been rigidly immobilized for weeks in a fixation dressing. While occasionally fractures are

2. *Physiology of Massage, this Handbook.*

encountered in which the application of physical therapy is impossible until union is complete, to wait so long in the vast majority is losing valuable time and unduly prolonging convalescence. Theoretically, physical therapy may be used advantageously in all three stages into which fracture treatment is divided, the reduction period, the postreduction period, and in after-treatment.

THE REDUCTION PERIOD

While unquestionably massage and elevation may be used with advantage to reduce swelling and quiet muscle spasm preceding reduction and the application of definitive splinting, to carry out such measures in a routine way demands a special setup and personnel which is rarely available. Practically, then, physical therapy can play but a minor role in the reduction period. However, when for any reason it is impossible to proceed with the immediate reduction of a fracture, even if the delay is but a few hours, heat and gentle massage may be used to advantage. When fractures are accompanied by severe trauma to the surrounding soft parts with extensive hemorrhage, and reduction, open or closed, must be delayed for several days, heat and massage may be used with considerable benefit to improve the condition of the soft parts and permit the application of definitive treatment much sooner than would otherwise be possible.

THE POSTREDUCTION PERIOD

In the postreduction period physical therapy should assume a very important role in fracture treatment, but unfortunately it is during this period that it is most neglected. It is in the immediate postreduction period that exudate and hemorrhage which will become organized into scar tissue about the muscles, tendons, vessels and nerves and interfere with muscle action, normal circulation and joint movement, can largely be removed by restoring as early as possible normal circulatory efficiency to the part. The stiffness, soreness and impaired function following a fracture are due in large part to such scar tissue and its removal or at least reduction to a minimum lessens the discomfort incident to restoring function and materially shortens the period of convalescence. Furthermore, in the light of recent investigations, clinical and experimental, it seems clearly established that delayed union and nonunion

are in the main traceable to interference with circulation at the fracture site so that early restoration of circulatory efficiency is our best safeguard against these catastrophes.

It is quite true that the application of physical therapy at this time is often difficult because the part is encased in a fixation dressing, but by the use both in bed and ambulatory cases of traction, which allows ready access to the part for physical therapy, through apertures in plaster dressings, by the use of hinged splints which allow movement in adjacent joints without disturbance of the fracture site, by the use of open splinting and by daily "setting" of the muscles, it is usually possible in most fractures to use heat, massage and muscle contraction throughout the period of fixation to the great advantage of the patient. So-called open splinting has in recent years been used more and more in the fixation of fractures; this permits the employment of physical therapy to a very satisfactory extent. By open splinting is meant using anterior or posterior or lateral molded plaster splints to replace circular plaster dressings when possible; as, for example, in Colles fractures, fracture of the patella and fractures of the ankle. Such splints afford ample exposure for physical therapy without disturbing the fracture. If a circular plaster dressing is used, it may be bivalved and the halves removed alternately for the application of physical therapy.

In addition to "setting" muscles in this postreduction period, active muscle contraction may be encouraged in several ways. Even with the forearm and arm encased in a plaster cast, if the fingers are free, the patient by squeezing and relaxing the grip on a rubber sponge can exercise the forearm and arm muscles extensively. Under the same conditions the shoulder and arm muscles will retain a large part of their tone and power if the shoulder joint is exercised regularly each day instead of holding the arm continually suspended and immovable in a sling. In Colles fracture, too often the elbow and shoulder joints are not moved and exercised, with the result that atrophy of the arm and shoulder muscles and limitation of movement in the elbow and shoulder joints prolong recovery while these avoidable conditions are being corrected. In leg fractures, systematic knee and hip exercises should be carried out each day to maintain muscle tone and

strength in the thigh and hip muscles so that the extremity will be better prepared to function when weight bearing is permitted. In these ways and others which naturally suggest themselves, muscles and joints may be kept active and the general strength of an extremity maintained in a state of reasonable efficiency.

THE PERIOD OF AFTER-TREATMENT

It is in the period of after-care that physical therapy is most generally used in fracture treatment. It is unfortunate that it is so frequently improperly used. The objective sought for in the after-care of a fracture is the restoration of normal use to the injured part after union of the fracture is complete and splints and restraints have been removed. The restoration of the ability to use the damaged limb normally or at least satisfactorily is possible only when muscles are active and joints movable. Muscle tone, flexibility and power can be built up only by progressively increasing active use of the muscles by the patient; a joint stiff or one with limited motion can become movable and reasonably useful only through the establishment of muscular control of the joint by the patient. It should be clearly understood that the range of passive movement which can be obtained in a joint is no criterion of its usability, since only that degree of movement which the patient can control is usable. Furthermore, until voluntary control of joint motion is established, ankylosis or serious impairment of the range of joint motion of a more or less permanent character is possible. The role of physical therapy in the after-treatment of fractures may be stated then to be helping the patient to regain voluntary use of the muscles and voluntary control of impaired joints of the injured extremity. Heat, massage and muscle stimulation can reduce swelling, can decrease pain, soreness and stiffness in weak and degenerated muscles, can improve vascular and lymphatic circulation, can stimulate neuromuscular and neurovascular impulses, can in brief make it easier for the patient to use the impaired part and build up voluntary control, but they cannot make him well. The patient, in the last analysis, is master of his fate, and physical therapy is but the tool which enables him to carve out his recovery with the least discomfort, the greatest speed and to the fullest extent.

In seeking to help a patient to regain voluntary control of the muscles and joints following a fracture, heat and massage should be used to loosen up and render more pliable muscles and so reduce the stiffness and pain incident to attempts at movement. The movements which are used should be designed to bring about normal action of the joint in the most natural manner. Various methods may be used to encourage the patient to use the extremity in a normal manner, such as having the patient go through the motions of brushing the hair in elbow fractures, driving nails with a light hammer in fractures of the wrist, turning a door handle in fractures of the forearm, and reaching for objects placed at a gradually increased height in shoulder fractures.

While emphasis has been laid on the basic forms of physical therapy, heat, massage, and muscle stimulation, it should be stated that there are varieties of these basic forms which may be used with satisfactory effect. Contrast hot and cold baths, the whirlpool bath and the hot paraffin bath may be mentioned as examples. The use of balanced weights on pulleys and various devices which encourage the patient to use joints with a restricted range of movement are most helpful. Also many types of apparatus have been devised which are helpful and enable treatment to be given efficiently and comfortably. Too often such apparatus is expensive and complicated and its use is but vaguely understood, so that it is employed according to directions given in a printed pamphlet which accompanies it from the manufacturer, who rarely underestimates what it will do or the number of conditions it will benefit. By all means let us be ready to take advantage of any advances and improvements which science offers, but let us demand that the criterion of the therapeutic effect expected from any piece of apparatus be a scientific and medically correct one and not an empiric one determined by its maker. Helpful as apparatus may be, it does not eliminate the element of judgment in how and when it should be used, nor can we blindly accept the statement of the maker as to its therapeutic effect. The accepted list of the Council on Physical Medicine of the American Medical Association is a reliable guide to apparatus which perform as claimed.

OCCUPATIONAL THERAPY

Any discussion of physical therapy in the treatment of fractures would be incomplete without mention of occupational therapy. Occupational therapy is a method of rehabilitation which is most useful in the treatment of fracture patients.

Occupational therapy is chiefly valuable because it supplies a real incentive for the patient to use the impaired part. A definite task is given him to perform and in spite of himself he becomes interested in completing it, with the result that he is inspired to renewed effort and unconsciously develops the attitude of mind which is necessary for recovery. Unfortunately, this form of physical therapy requires trained attendants and some apparatus so that its use is largely restricted to centers where these requisites are available; ingenuity, however, may work out simple tasks which may replace apparatus for rehabilitation training. Light carpentry, which requires the use of hammer, plane, saw and sandpaper, is available everywhere and is a useful type of occupational therapy for restoring function in the upper extremity. Gardening, painting and a variety of other simple occupational pathways may be utilized to improve joint motion, increase muscle strength and control and, above all, build up the patient's morale and help him progress from the passive role of a recipient of physical therapy to an active role of one who is giving himself physical therapy. Occupational therapy is a very useful way of overcoming the subconscious resistance of the patient to normal use of an injured part for fear he will suffer a relapse. It is often a useful bridge over the hiatus between return of use and return to normal life and activity.

AMOUNT TO BE USED

Finally, some mention should be made of the amount of physical therapy which may be used. There is but one reliable guide as to whether physical therapy is being given properly and that is the reaction of the patient. Physical measures may be used up to the point of pain tolerance provided the painful reaction subsides within an hour or two. Physical therapy which produces painful reaction and muscle spasm that persists until the next treatment indicate too forceful or too prolonged treatment and both amount and dura-

tion must be reduced; persistence can lead only to resistance on the part of the patient, slowing up of recovery, and a disappointing result.

CONCLUSION

In the treatment of fractures physical therapy has a most important role. Used intelligently in the post-reduction period it will reduce scar tissue, infiltration of muscles, tendons and joints, maintain a satisfactory state of the circulatory apparatus and greatly reduce the period of after-treatment. Properly employed in the after-treatment it will help the patient to do his part, which is building up that voluntary active use of the impaired extremity which alone can restore function, hasten his recovery and complete the cure.

PHYSICAL THERAPY IN INFANTILE PARALYSIS

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Infantile paralysis (poliomyelitis) in epidemic form is more prevalent during the late summer and early fall in this country than at any other time of the year. It would therefore seem pertinent to discuss the early orthopedic, nursing and physical measures which are so necessary in preventing crippling and in restoring as much function as possible in each case. It must be remembered that some of these children die from the disease in the early stages, some of them are not paralyzed at all, some of them are partially paralyzed and some are almost totally paralyzed. The paralysis varies with each patient. A few of the paralyzed show no power of recovery whatever, but the majority may recover more or less muscular power and a complete recovery is not uncommon.

Lovett in his monograph divided the disease into three stages, first, second and third.

THE FIRST STAGE

The first stage, or the acute stage, lasts from the onset until muscle and nerve pain and tenderness disappear. It is during this stage that all the resources of the attending physician, nurse and orthopedic surgeon are so often needed. Treatment during the febrile portion of the acute stage is mainly that of medical and nursing care, but as soon as the fever has subsided the attending physician should not consider that convalescence has begun, as is true in many other conditions, because by no possible chance can the lesion in the spinal cord be healed, since this is a matter of several weeks (eight at least). It is during this time that the patient is very apt to be exquisitely tender in his legs, calves, thighs, hips, back and also in the adductor region of the shoulders. Sister Kenny [1] points

1. "Kenny Concept of Infantile Paralysis and Its Treatment," by John F. Pohl, M.D., published Bruce Publishing Co., Minneapolis.

out "that there is muscle spasm in the paralyzed muscles." This spasm may be due to the muscle soreness and is part of a reflex protective mechanism or it may be due to a pathologic process in the elements of the spinal cord. The tenderness is not always confined to the paralyzed members. There may be as severe pain and sensitiveness in the unparalyzed extremities. Patients who are very sensitive in these parts may assume protective positions of flexion in order to relieve pain and thereby develop deformities. To prevent such conditions occurring, properly covered and padded wire splints must be applied to hold the extremities in the position of comfort. One will find that after a few days the deformities will gradually straighten out and, as they do so, the wire splints can be straightened as the tenderness disappears. Sedatives may be necessary. On no account should efforts be made to stretch out flexed limbs while they are tender. The use of hot packs or, better still, if the patient can stand moving, a deep hot bath for a few minutes each day are the two best forms of heat to be used in relieving and relaxing the sensitive extremities. There seems to be more beneficial results when hot packs are used early in the acute stage and when applied frequently as advocated by Sister Kenny. Dry heat in the form of lamps or diathermy has no advantage over these methods. As the soreness disappears, flexed limbs will gradually straighten out and the splints may be adjusted accordingly. The splints are useful in relieving pain and preventing deformities and should not be discarded unless one is sure that the continuous hot pack method will be properly carried out.

There are a few simple procedures for eliciting sensitiveness. In the lower extremity gentle straight leg raising by the examiner will produce pain in the leg; attempts at passive dorsal flexion of the foot will produce pain in the calf; deep slow pressure of the calf muscles, thigh muscles and hip muscles will elicit pain if these are still sore. In the shoulder, attempts at passive abduction or pressure on the axillary groups of muscles are the two methods for eliciting tenderness.

No massage or exercises should be started during the stage of tenderness, since they do nothing but increase the pain and delay favorable progress. Absolute rest in bed and daily hot packs or hot baths at

a temperature of 105 F. must be insisted on, since these are more effective than any other form of therapy The patient will often move his extremities a little in the hot bath without detriment.

THE SECOND STAGE

As soon as all the signs of tenderness have disappeared, rehabilitation should be begun by an expert physical therapy technician who has a complete knowledge of muscle function. Deformities must be prevented if possible by proper attitudes of the patient and careful splinting of the extremities and back if necessary. The physical therapy technician should make a complete muscle examination in order to evaluate the loss of power in each muscle or each group of muscles as the case may be. The tests are necessarily rough ones but serve the purpose very well. The muscle function tests are based on gravity and the key is as follows:

Normal: Against gravity plus normal resistance.

Good: Against gravity plus resistance under normal.

Fair: Against gravity without resistance.

Poor: Horizontal plane eliminating gravity.

Trace: Not able to carry through arc of motion but contraction can be felt by finger.

No power: No contraction can be felt.

The muscle power is charted as shown in the accompanying illustrations and from this chart one gets a very good idea of the individual problems that one has to meet in the way of function. Mild baking with electric light lamps and gentle massage promote the circulation in the muscles. These should be followed by active exercises of the affected muscle or group of muscles. If the muscles are too weak to function against gravity and friction, these should be removed. Exercises given in a pool or tank of warm water eliminate friction. It is very simple to construct a house tank of galvanized iron about 2 feet in depth, 4 feet in width and 6½ feet in length. The effect of gravity may be eliminated by having the moves made parallel to the table.

The strong muscles must not be treated at the expense of those that are weakened. As soon as a muscle shows the first sign of flagging, it should be

rested. During the early part of the convalescent stage, complete rest must be insisted on. The length of time of rest depends on how fast recovery takes place and on the amount of paralysis present. Braces and splints must be worn to keep the extremities in the most favorable position for recovery and also to relieve stretching of paralyzed muscles. The duration of the physical

Name

Record No.

Characteristic gait

LEFT					RIGHT			
Date	Date	Date	Date		Date	Date	Date	Date
				Facial				
				Neck				
				Sternomastoid				
				Suprahyoid				
				Infrahyoid				
				Deep flexors				
				Back				
				Anterior) Abdominal (Anterior				
				Lateral) Abdominal (Lateral				
				Legs				
				Calf) Measurements (Calf				
				Thigh) Measurements (Thigh				
				Length) Measurements (Length				
				Gluteus maximus				
				Ilio psoas				
				Sartorius				
				Tensor fasciae latae				
				Hip abductors				
				Hip adductors				
				Inward rotators				
				Outward rotators				
				Quadriceps				
				Inner) Hamstrings (Inner				
				Outer) Hamstrings (Outer				
				Gastrocnemius				
				Tibialis anterior				
				Tibialis posterior				
				Peroneus longus				
				Peroneus brevis				
				Extensor digitorum longus				
				Extensor digitorum brevis				
				Extensor hallucis proprius				
				Flexor digitorum longus				
				Flexor digitorum brevis				
				Flexors of the proximal phalanges				
				Flexor hallucis longus				
				Flexor hallucis brevis				

The chart of muscle power is a sheet of paper measuring 8 by 14 inches with lists of muscles on the front and back of the sheet. This is the list on the front of the chart.

treatment should be indefinite; i. e., it must be continued as long as recovery can be demonstrated.

Early walking should be discouraged. For a moderately paralyzed patient whose morale is low, simple walking splints may be applied and the patient allowed to walk a little each day; but he should not be allowed to get fatigued. It must be remembered that walking does not increase the strength of the

muscles. If it is obvious that the patient is not going to make any recovery whatever, that is, complete paralysis of the lower extremities, he should be taught to walk with braces and crutches. If a patient has one

LEFT					RIGHT			
Date	Date	Date	Date		Date	Date	Date	Date
				Deltoideus anterior				
				Deltoideus posterior				
				1) (1				
				2) Trapezius (2				
				3) (3				
				4) (4				
				Serratus anterior				
				Rhomboidii				
				Latissimus dorsi				
				Superior) Pectoralis major (Superior				
				Inferior) (Inferior				
				Pectoralis minor				
				Outward rotators				
				Inward rotators				
				Biceps brachii				
				Brachialis anticus				
				Brachio-radialis				
				Triceps				
				Supinator				
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				1) (1				
				2) Palmar interossei (2				
				3) (3				
				Opponens pollicis				
				Abductor pollicis brevis				
				Adductor pollicis				
				Flexor pollicis longus				
				Flexor pollicis brevis				
				Abductor pollicis longus				
				Extensor pollicis longus				
				Extensor pollicis brevis				

List of muscles on the back of the chart.

good hand, a good arm and good back muscles he can be taught to get out of a chair, to walk and go up and down stairs. Being able to do these three things makes him independent.

THE THIRD STAGE

The third stage is usually represented by the end of the maximum recovery of power of muscles and has been arbitrarily placed at two years. It is not uncommon for muscle power to go on increasing for many years after this. It is during this stage that fixed deformities must be relieved by operative measures such as arthrodeses and tendon transplantations. During the period of immobilization after each procedure, a physical therapy technician should teach the patient how to exercise the limbs to improve function and how to exercise the transplanted muscle so that it will take on the function of the muscle for which it is substituted.

It must be remembered that in the rehabilitation of an "infantile," a physical therapy technician plays a large part, so that it is of vital importance that the technician employed should be well trained in the treatment of these cases. If it is possible, the patient should have the attention of an expert technician who can teach some member of the patient's family the necessary exercises and then check up on them from time to time. The Council on Physical Medicine believes that electricity has no place in the treatment of infantile paralysis.

PHYSICAL THERAPY IN PSYCHIATRIC PRACTICE

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The interest of psychiatrists in physical therapy perhaps antedates that of any other medical specialty. This is particularly true of that form of physical therapy known as hydrotherapy; in hippocratic times baths were used for treating mental patients and during the Renaissance the noyade, a rather drastic form of hydrotherapy, was frequently employed. There is probably no mental hospital in the country today which does not have some hydrotherapeutic installation, and the continuous tub and the wet sheet pack have long been standard procedures in such hospitals. Perhaps too the earliest therapeutic uses of electricity were those in connection with psychiatric practice, even though the effects of the static spark and more recently of the faradic current in connection with the treatment of the neuroses were largely suggestive rather than primarily physical.

Physical therapy and psychiatry have labored under rather similar difficulties in that they are both newly recognized specialties of medicine even though their practice is old. Both have developed rapidly; the former has learned much of the various modalities and their effects, the latter of mental mechanisms and their psychosomatic relationships. One point which has gained general recognition is that the patient is a unity, that the mind is not separate from the body, that what one calls mental is but another aspect of the functioning of the whole organism. The manner in which the integrated organism functions and in which its various organs operate affects the emotional state of the patient; the converse is equally true. As knowledge of the bodily factors in mental states has developed, the utilization of physical therapy in psychiatric practice has gained. In addition to the direct effect on various bodily organs and organ systems, however, an effect

is exerted on the whole patient by anything which modifies his physical environment, whether this is within his body, on the surface of his body or in the world about him. It is these effects on the whole patient which are referred to as psychologic.

One of the forms of psychologic treatment is known as suggestion. The old fashioned family doctor, whose very entrance into the room breathed assurance and optimism and who made his patient feel better immediately, has long been a byword. Strangely enough, however, the textbooks and many articles which deal learnedly with the effects of the various forms of physical therapy on blood pressure, circulation, secretory activity and other functions of the organs fail almost totally to mention this important psychologic aspect of physical medicine. Just as in the time of Mesmer and his magnets, various phenomena were observed in patients which are now recognized as having been due entirely to suggestion; this fact has unfortunately been seized on occasionally by the less scrupulous. The imposing static machine and some of the more recent types of apparatus, particularly those designed by quacks to impress the unwary, are potent instruments of suggestion. Physical medicine has had to fight against the idea that it is quackery, and it has had to set standards of apparatus and standards of education and practice, tasks which have been extremely well carried out. The quack gives positive assurance, and the more of a quack he is the more positive the assurance. This is precisely what some patients need. When assurance is combined not only with a strong personality but with imposing apparatus, whether that apparatus is soundly constructed or designed merely for appearances, a psychologic effect is readily produced. Under the control of the qualified practitioner this effect can be a powerful asset.

It should be emphasized that it is not a criticism of physical therapy or of any other reputable branch of medicine that it produces psychologic effects. The tangible effects of the various procedures employed by physical medicine are demonstrable and well known. The fact that there are positively suggestive effects at the same time simply reinforces the local effect of the modality and serves as an adjuvant if one recognizes those effects; by ethical and wise utilization of them

the welfare of the patient is promoted and the desired therapeutic result is hastened.

First of all, the patient perceives that something visible and tangible is being done to help him; this in itself is a powerful lever in securing his cooperation and help. He feels reassured and is grateful for the personal attention that is being given to him. Every psychosis or neurosis represents the presence of a conflict in which there is an attempt to satisfy emotional needs, many of them entirely unconscious. Here again the various procedures give an opportunity to gain a certain amount of satisfaction of these needs. Conversely, there may be emotional conditionings which should be taken into account in dealing with the patient, conditionings which may cause him to be fearful of certain procedures. For example, a patient who has had a narrow escape from drowning may become fearful in the presence of a prolonged bath, whereas he might not have the same feeling toward a wet sheet pack. The attitude with which the patient approaches the treatment, therefore, and that with which the therapist approaches it will have much to do with the effect on the patient. This is true in general practice; it is even more important in a mental hospital.

In psychiatric practice two general classifications of physical therapy may be made. One includes the types which are prescribed primarily on account of the total behavior of the patient, that is, on account of his mental condition; such are, for example, the continuous bath and the wet sheet pack for states involving tension, overactivity and restlessness, and the various forms of stimulative therapy, such as the contrast douche, the salt glow, the friction rub and ultraviolet therapy, which may be utilized in states of depression and decreased motor activity. In the other group are included numerous other forms of physical therapy which are useful even though they are directed toward systemic conditions or the conditions of particular organs. The latter group of modalities likewise have a beneficial effect on the mental state of the patient, although this effect may be referred to as in some ways a by-product.

SEDATIVE HYDROTHERAPY

Continuous Bath.—Of the forms of physical therapy prescribed for primarily psychiatric reasons, the form which is by far the most commonly used is the con-

tinuous neutral bath. For reasons of economy of personnel the continuous bath suite should contain several tubs rather than a single one. The walls should be of a neutral tint, such as green or gray. The usual tub is large, usually about 33 by 78 inches and about 20 inches deep. It is equipped with four or more inlets in order that the flow of water may be assured, with buttons for the attachment of a hammock and with a 4 inch outlet in order that the tub may be emptied rapidly in an emergency. A thermostatic mixing valve should be used, but the attendant, who should always be present in the room, should utilize a bath thermometer frequently and should occasionally test the temperature of the water with his hand as well. The use of a hammock adds somewhat to the comfort of the patient, although it is not essential. Opinions differ on the value of a tub cover. A cover which is firmly fastened is likely to give a feeling of imprisonment to the patient and sometimes encourages active resistance rather than sedation. Ordinarily a sheet will serve the purposes of warmth and modesty. The room should preferably be not too light, and it is better to have the tubs separated by movable screens. The temperature of the water is best held at about 94 to 96 F., and a moderate flow should be maintained. Every effort should be made to prevent the variations from being pronounced, and special care must be taken not to allow the temperature to go substantially either higher or lower. The bath may be continued for rather long periods if indicated, and it is doubtful whether much effect is obtained in less than three or four hours. There is no objection to a patient's remaining in a continuous bath for several days without interruption. In a few patients a cutaneous eruption is noted after a period, but this usually responds promptly to emollients. This form of treatment is essentially sedative and therefore is most frequently utilized in conditions of overactivity and restlessness such as may be found in delirium tremens or other deliriums, in dementia paralytica, involutional melancholia, the manic phase of manic-depressive psychosis, disturbed forms of schizophrenia, and even in not too debilitated senile psychoses. As contraindications one may mention pulmonary tuberculosis and extreme debility.

One of the great advantages of this form of therapy is that it can be used without special equipment, as in the general hospital or in the home. Important precautions to take are those against scalding or chilling and against attempted suicide by drowning. The value of being able to empty the tub quickly in any of these emergencies is obvious. The need of constant supervision in this form of therapy cannot be stressed too strongly.

The use of the warm bath to promote sleep need hardly be elaborated on here.

The Wet Sheet Pack.—Next in point of frequency to the continuous bath is found the wet sheet pack. This is a valuable sedative measure but one which is not without its dangers, both physiologic and psychologic. A considerable degree of technic is required for the proper application of the pack, and there is some dangers of collapse or heat stroke if the patient is not properly supervised during the administration of the treatment or if the treatment is continued for too long a period. The pack combines the advantages of a vapor bath with enforced immobilization, both of these elements being essentially sedative in effect. Unfortunately in some institutions the indiscreet remarks of attendants have sometimes, by threatening the patient with a pack, given the impression that this procedure is punishment rather than treatment. Such a mental attitude on the part of the patient is likely to result in increased struggling, thus nullifying the sedative value of the treatment. Usually, however, when the therapeutic purpose of the pack is impressed on the patient, there is not only no opposition but an eagerness to accept this form of help.

The amount of equipment required for the wet sheet pack is relatively slight. Preferably a pack table (about 30 inches high) rather than a bed is utilized, and sheets and blankets with safety pins are essentially the only other material needed. The mattress should be firm and should be covered with a rubber sheet. For somewhat debilitated patients the pack may be preceded by a brief warm tub bath or a steam or electric cabinet treatment for the purpose of increasing the circulation in the skin and raising the general temperature of the body. The room should be warm, not less than 70 F., somewhat darkened and quiet, and the walls painted a neutral

tint. The sedative effect is heightened if the patient is separated from other patients in the room by screens. The best effects are obtained if the sheets in which the patient is first enveloped are wrung out in water at a temperature of 60 to 70; that is, cool. An extremely vigorous patient may react well to water even slightly below 50 F. A frail patient, on the other hand, requires water of a more nearly neutral temperature, between 92 and 97 F. The secondary stimulation of surface circulaton is heightened with the cooler water. Sheets should always be wet. The dry sheet pack is dangerous and should never be employed. Sheets wrung out in hot water, on the other hand, may scald the patient, and for this reason hot water should not be used.

The patient should be enveloped as rapidly as possible in the wet sheets and then wrapped in blankets to prevent radiation.[1] The proper technic is rather complicated and need not be described here. The successfully applied pack will remain in place with at least a moderate amount of motion of the patient. Suitable care must be exercised to prevent the patient from rolling off the table. In the initial stages of the pack it is desirable that cold be applied to the occiput and forehead, but as soon as the flushing has subsided this may be discontinued. The patient should show substantial sedation and may even go to sleep within about forty-five minutes. If he does not, he should be removed and given a continuous bath instead.

A patient in a pack must be carefully supervised with particular regard to his pulse and to the presence of flushing. If heat stroke appears imminent, he should be removed from the pack immediately. In any event the pack should not be continued more than four hours, as heat exhaustion may take place if it is continued longer. After the patient is removed a brief neutral shower may be given, and he should then be placed in bed and covered warmly for a period of rest. Liquids may be given while the pack is in progress, but the patient should not be fed. A considerable amount of perspiration takes place; one of the advantages of the pack is that it stimulates elimination through the skin. A cooperative patient may be placed in a pack by as few as two nurses, but in some instances the services of three or four are necessary.

1. See page 185 of Handbook of Physical Therapy.

This is a procedure which may be utilized in the home or in the general hospital, with adequate supervision of trained persons. It is extremely useful in states of disturbance and overactivity, such as those in which the continuous bath may be used. It is more actively sedative and therefore is applicable in some cases in which the continuous bath would not be considered as the first choice. The frequency of prescription, and indeed of prescription at all, will depend much on the general physical condition of the patient. Pulmonary tuberculosis is generally looked on as a contraindication, as is hyperthyroidism, or any other condition in which cerebral congestion should be avoided.

STIMULATIVE HYDROTHERAPY

Under the general heading of stimulative hydrotherapy one finds a number of procedures, all more or less related and somewhat similar in principle, involving the application of cool water which is under more or less pressure and of various temperatures, accompanied or not by friction. The particular varieties depend in part on the physical condition of the patient and on his general cooperativeness. They are particularly useful in mental conditions characterized by a tendency to inactivity as, for example, in the depressions and those types of schizophrenia in which catatonic features are rather prominent. Some of them, in order to increase the contrast and reaction, may be preceded by a brief period under close observation in the electric bath cabinet or the vapor cabinet. In general, however, these particular forms of the application of heat are of doubtful value in psychiatric practice. Considerable hazard is involved in any event, and with a disturbed patient burns may be incurred.

Douches.—The needle or circular type of douche is in common use. This has the advantage of stimulating the entire surface of the body by the impact of numerous fine jets of water, and the thermal effect may be varied according to the patient's ability to react. The same may be said of the fan and jet douches, which involve somewhat more massive stimulation. One of the most stimulating forms of all is the so-called contrasting or Scotch douche in which two alternating streams of water, one 70 to 80 and the other about 110 F., are applied by a hose under considerable pressure.

Other Forms.—Saline baths are spoken of in the literature, but they are not used with any great generality. The same may be said of the effervescent or so-called Nauheim bath. The applications of the whirlpool bath, although it might be used for its general effect, are more often for localized conditions. Affusions and the drip sheet rub are other forms of stimulative hydrotherapy which may be mentioned.

Salt Glow and Friction Rub.—Among other types of physical therapy involving water and friction may be mentioned the salt glow, which consists in rubbing the surface of the skin with damp coarse salt, and cold mitten friction, the operator using either fiber mitts or preferably knitted mittens on his hands. These procedures may be applicable in the postdelirious state and may be useful with some of the types of neurosis in which general supportive and stimulative therapy is called for.

Irrigations.—Another form of the application of water is found in the irrigations, such as the enema, the vaginal douche and the colonic irrigation. These procedures are discussed elsewhere in the Handbook.

THE FEVER CABINET

An important form of physical therapy in mental hospitals is found in the use of the fever cabinet. The original work of Wagner-Jauregg in Vienna in 1917, subsequently introduced into the United States at St. Elizabeths Hospital, consisted in malarial inoculation of patients suffering from dementia paralytica. Certain drawbacks to malarial therapy have been mentioned, two of the notable ones being that certain persons are immune to malaria and that the physical condition of others does not permit inoculation with malarial parasites for therapeutic purposes. Accordingly, for a number of years a good deal of investigation has been carried on concerning the artificial induction of fever (diathermy, electric blankets and so on) and several satisfactory types of fever cabinet have rather recently been developed. A certain amount of cooperativeness is requisite on the part of the patient, and close supervision must be exercised at all times by the nurse, who should have special training in this form of therapy.

The patient, without breakfast, is placed in the cabinet, and his temperature (taken continuously by an electric rectal thermometer) is gradually raised to approximately 106 F. It is maintained at this level for about six hours and then is gradually reduced. During the treatment fluids are forced, and the treatment must be followed by prolonged rest. Heat prostration and even death from fever treatment are not entirely unknown, and care must be exercised in the selection of the patient. A total of about fifty hours of fever is administered in conjunction with active chemotherapy. Any contraindication to a major surgical operation is a contraindication to fever therapy. In addition, organic lesions of the brain (other than dementia paralytica), arteriosclerosis, any extensive areas of anesthesia and hepatic disease are all contraindications.

ELECTRIC SHOCK THERAPY

Another form of physical therapy which is highly characteristic of mental hospitals and which indeed should not be employed outside of a hospital is the so-called electric shock therapy. By means of a special apparatus a current of low amperage (300 to 700 milliamperes) may be passed through the brain by means of electrodes applied to the temporal regions while the patient is lying supine in moderate hyperextension. This position is readily obtained through the use of sand bags or pillows or by means of a Gatch bed, the patient lying with his head at the foot of the bed. The current is applied for 0.1 to 0.7 second and immediately causes a convulsive seizure with loss of consciousness. The convulsion lasts approximately one minute, followed by a period of confusion which may last five or ten minutes and by a period of anterograde amnesia. Sometimes impairment of memory is a persistent complaint. During the convulsion the motions of the extremities are best controlled by two or three suitably trained attendants. The treatment has been recommended particularly for the depressions, and in some cases remarkable improvement at least of a temporary nature has been reported. It has also been used occasionally for conditions of overactivity, especially for the manic phase of the manic-depressive psychosis, and with somewhat less success for the various manifestations of schizophrenia. The rationale of the procedure is a subject of speculation.

REFRIGERATION

Some investigation of the effects of low temperature has been carried on in a few psychiatric centers but with dubious results. By means of a specially constructed unit, refrigerated brine is circulated through tubes in a rubber blanket, the patient being thoroughly wrapped in woolen blankets. The general temperature of the body is lowered gradually to about 85 F. or even lower. Some of the hypothermic treatments have lasted forty-eight hours or more. One case of a minimal temperature of 74.6 F. (with survival) has been reported. The procedure is not recommended.

The local effects of cold for cauterization and for local surgical anesthesia are dealt with elsewhere.

OTHER MODALITIES

I have discussed so far the various forms of physical therapy which are prescribed primarily on account of the behavior of the patient and which have psychologic indications. The extent of physical therapy in psychiatric practice, however, is not limited to this recitation. In the course of psychiatric practice either inside or outside a hospital almost any sort of physical condition may become intercurrent or associated and call for physical therapy. For this reason any well equipped psychiatric hospital needs to have an active physical therapy department and to be prepared to administer such of the well known modalities as short wave and surgical (electrocoagulation) diathermy, infra-red and ultraviolet radiation, and polysine.

The private practitioner in the field of psychiatry too will often have occasion to utilize the tools of physical therapy for both general and specific effects. Massage should be available for its local effects on disabled joints and muscles and for general relaxation as well. Reference to the other chapters in the Handbook will indicate the range of types of disability which the physical therapy department of a mental hospital is called on to treat. Patients in mental hospitals, in other words, exhibit little difference from patients outside. They are perhaps more susceptible to what may be termed the intangibles—atmosphere, personality, attention to their needs and interest shown in them. This difference, however, is only one of degree. Occasionally they are somewhat less cooperative than the

average patient in general practice, and occasionally they are even resistive. Many of them, however, are highly cooperative and deeply appreciate all that is done for them. The effects of specific treatment on their general mental health are often startling.

Much can be done to make the physical therapy department attractive. Hangings, pictures, mirrors, plants and even birds and aquariums do much to dispel the formal institutional appearance of the average treatment room. The matter of emphasizing the attention being given to the patient is one which might well be borne in mind in general. Such details of atmosphere do much to promote relaxation, stimulate the cooperation of the patient and put him in a psychologic condition to receive the maximum benefit from his treatment.

THE TREATMENT OF SKIN DISEASES BY PHYSICAL METHODS OTHER THAN RADIATION

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In this article the physical therapeutic methods, other than the various types of radiation, commonly used in dermatologic practice will be discussed.

HIGH-FREQUENCY CURRENTS

Currents of high frequency are employed in dermatology in several ways and for various purposes. Their widest range of usefulness is for the production of heat within the tissue. When tissue is heated to a temperature insufficient for its destruction but sufficient for therapeutic effect, the application is known as medical diathermy. If the amount of heat is sufficient to destroy tissue by coagulation or by dehydration, the application is called surgical diathermy. Medical diathermy is used to some extent in dermatology; surgical diathermy is used a great deal.

A number of terms have been coined to designate the type of current used or to indicate its effect on tissue. This has led to a confusing and at times contradictory nomenclature. In this article the following nomenclature will be used:

1. Medical diathermy: The use of a high-frequency current for medical purposes.

2. Surgical diathermy: The use of a high-frequency current for surgical purposes.

A. Cutting current (biterminal high-frequency current) obtained from the primary winding of the high-frequency transformer.

B. Electrocoagulation: Biterminal (and at times monoterminal) high-frequency current obtained from the primary winding of the high-frequency transformer.

C. Electrodesiccation: Monoterminal high-frequency current from the secondary winding of the high-frequency transformer.

The detailed physics of high-frequency currents and a description of apparatus will not be given here. They are discussed elsewhere in this book and descriptive catalogues are supplied by manufacturers. All that is necessary is to explain some of the terms used in this article. Briefly, high-frequency currents are usually obtained in the following manner: The street current is stepped up in voltage by a small conventional transformer. Oscillations or high frequencies are obtained by means of condensers and a spark-gap or oscillating tube. The oscillating current is again stepped up in voltage by means of another coil or transformer which may be called the high-frequency transformer. The primary of this transformer consists of a few turns of heavy wire. This was formerly called the solenoid. The secondary coil consists of many turns of fine wire and was originally called the resonator. The secondary may be wound around the primary or the two coils may be connected end to end. Originally, current from the primary was known as the d'Arsonval or solenoid current, while that from the secondary was called the Oudin or resonator current. These terms are now obsolete. Each turn of wire provides higher voltage and lower milliamperage. Taps taken from different portions of these coils provide currents of different voltage and milliamperage and are used for different purposes—coagulation, cutting and desiccation.

General Technic of Application.—The effect on tissue will depend on the voltage, milliamperage and the manner of application. When current from the primary winding of the high-frequency transformer is applied so that some part of the body is between two large electrodes, the tissue between these electrodes will become heated—medical diathermy. The entire surface of each electrode must be in contact with the skin. It is customary to begin with about 200 or 300 milliamperes, which may be increased gradually to 3,000 or more, depending on the patient's toleration and the size of the electrodes. The larger the electrode, the greater the amount of current tolerated as a rule. Applications for dermatologic purposes last usually from ten minutes to a half hour. Long treatments with mild current seem preferable to short treatments with heavy current.

High-frequency currents, short and ultrashort Hertzian waves, hot-air cabinets, and other devices are used for the production of hyperpyrexia. So far as concerns skin diseases, fever therapy is now in the experimental stage and has not been evaluated. As this subject is discussed elsewhere in this book, it will simply be mentioned here.

If the same current is applied by means of a pointed needle electrode inserted into the tissue with a large dispersive electrode on some other part of the body, there is coagulation or destruction of tissue in the vicinity of the needle—electrocoagulation. The destruction may extend from one to several millimeters in all directions. The small blood vessels and lymphatic vessels are occluded. The length of application for each insertion is usually from one to several seconds.

One objection to electrocoagulation is the difficulty of accurately controlling the amount and extent of tissue destruction. This may be obviated to a considerable degree by using a biterminal electrode—two needles about 2 mm. apart. With such an electrode, both needles of which are active, the current passes from needle to needle and coagulation is confined to the tissue between the needles. Electrocoagulation can be performed, also, with monoterminal high-frequency current.

The same coil also supplies the cutting current. The indifferent electrode may be a wet towel held in contact with the forearm with a metal clamp. The other pole is usually a needle. The current from the point of the needle cuts as quickly as does a sharp scalpel. There is slight coagulation of tissue and there is occlusion of the small lymphatic and blood channels. With a finely adjusted current there is very little gross coagulation or charring, but there is always some. Instead of a needle electrode, one may use fine wire loops of various sizes. Loops are at times advantageous for snaring off small benign tumors and for other purposes that will be mentioned later. The needle electrode is the one employed as a routine.

The current for electrodesiccation (monoterminal) is obtained from the second winding or coil of the high-frequency transformer. The biterminal and monoterminal currents from the primary winding cause death of tissue by coagulation. These currents are more suitable

for deep, drastic destruction of tissue. Current from the secondary winding is more easily controlled, more flexible. The effect is that of desiccation or mummification. By proper adjustment of controls one can desiccate an area of skin or mucous membrane the size of a pin-head. The current is obtained from a spark gap machine and must arc between the needle and the lesion.

Treatment may consist in instantaneous contact between needle and skin in the case of a tiny, superficial skin lesion; or the current may be allowed to act for several or many seconds, mummifying the tissue to a depth of one or several millimeters. In the case of larger and deeper skin lesions, the needle may be inserted into the growth. By multiple insertions and heavy current (primary winding) it is possible to destroy completely a large tumor of the skin or mucous membrane.

Different lesions require different strengths of currents. For large lesions heavy sparking is used and for smaller lesions light sparking is required. Therefore, with a properly adjusted current, wounds may be made completely dry, with cessation of oozing and hemorrhage from small vessels. With a heavy current (primary winding) the needle is held against bleeding points from one to several seconds, after which the entire wound is bombarded with coarse sparks (secondary winding), the surface becoming dry and charred.

There are no detailed standards for high-frequency apparatus. The currents from different machines will vary somewhat in characteristics. It is necessary, therefore, for the physician to become acquainted with the peculiarities of his apparatus. When using current for surgical diathermy it is customary to employ either a foot-switch or a spring contact on the needle holder. The instrument panel contains plainly marked controls and switches.

Most high-frequency machines are equipped with a hot-wire milliamperemeter which may be used with biterminal current from the primary winding (medical diathermy; biterminal electrocoagulation; cutting current) but not with the monoterminal currents. Too much reliance should not be placed on the milliamperemeter. Milliamperage is not an accurate guide to the production of heat or to the amount of destruction of

tissue. Also, heat production and coagulation depend on details of technic such as size and shape of electrode, resistance offered by various tissues, the time factor, and characteristics of the particular apparatus.

General Therapeutic Considerations (high-frequency currents).—Diathermy is far from being a safe method in unskilled hands. Carelessness and ignorance when applied to medical diathermy may result in undesirable injury to the skin and even to the underlying structures. Surgical diathermy may cause injuries which are objectionable, painful, disfiguring and at times dangerous.

The intelligent and proper use of surgical diathermy requires a knowledge of the general principles of surgery. Major surgical diathermy is best applied by those who have had extensive experience with scalpel surgery. Minor surgical diathermy is within the reach of most physicians.

When employing electrocoagulation, one must take care not to destroy important, normal, adjacent tissue unnecessarily. Also, hemorrhage must be guarded against. During the application of the current there may be no hemorrhage because small vessels are occluded, but a large, adjacent vessel may be damaged just enough to cause a severe postoperative hemorrhage.

The cutting current seals small vessels but not the large ones. Hemorrhage from the larger vessels can be controlled often by applying to the vessels for a second or two a strong monoterminal coagulating current. However, it is preferable to ligate large vessels either before or during the operation.

The coagulating and desiccating currents seal the lymphatic vessels completely. The cutting current does the same but not so thoroughly. Advocates of surgical diathermy believe that this instantaneous occlusion of lymphatic vessels prevents metastasis of malignant tumors. When dealing with an accessible malignant tumor, it is customary to produce a ring of coagulation well beyond the periphery of the lesion. The tumor is then thoroughly coagulated, and the entire mass is removed with curet, scissors or cutting current. Finally, the wound is electrodesiccated and dressed. It is usually advisable to remove tissue that has been thoroughly coagulated, in order to prevent subsequent infection.

The advocates of the cutting current aver that the incision may be sutured and that primary union will follow. This is true, but primary union often fails. It is less likely to fail if the incision is freshened with scissors, scalpel or curet before it is sutured.

Nearly all surgical diathermy operations require either general or local anesthesia. Surgical diathermy machines should not be used in the presence of combustible anesthetics; when necessary, resort should be made to noncombustible and local anesthetics. It is surprising how often physicians will attempt to destroy a small growth (basal cell epithelioma for instance) with high-frequency currents without anesthesia of any kind. Without local anesthesia it is usually impossible to do the work thoroughly or properly. In dermatologic practice there are some lesions that require only an instantaneous application of the electrodesiccation current. In such instances an anesthetic is unnecessary. But as a rule some kind of anesthesia is essential. Surgical diathermy requires the same attention to asepsis as does scalpel surgery. Hypertrophic scars are rather common subsequent to the various kinds of surgical diathermy.

ELECTROLYSIS

A current suitable for electrolysis may be obtained from wet or dry cells. The voltage employed for electrolysis is low, 22½ volts; the milliamperage is usually from one-fourth milliampere to 1 or 2 milliamperes. Devices for use with commerical direct and alternating currents are on the market but the physician should inquire whether these have been accepted by the Council before purchasing such units. A cheap, convenient and satisfactory apparatus for dermatologic practice consists of a 22½ volt dry battery such as is used with radio receiving sets. This is placed in a small cabinet on which is mounted a milliamperemeter, a rheostat and binding posts. These posts should be plainly marked positive and negative, and the operator must be certain that the polarity is correct.

The active negative electrode is a needle. For delicate work, particularly for hypertrichosis, exceedingly thin needles specially made for this purpose are obtainable. When steel needles are used, it is especially important to be certain of polarity, because with a positive current and a steel needle permanent black

marks are likely to occur. For this reason many physicians prefer platinum needles. Some physicians prefer to use multiple needles—various devices employing multiple needles are on the market. The majority, however, favor a single needle because of better control of the result. The dispersive positive electrode is of the sponge type. It should be wet with normal sodium chloride solution and may be held in the patient's hand.

The term electrolysis is an old one in dermatology. In the past decade the terms medical and surgical ionization have come into use. The latter term is incorrectly used, for surgical ionization is electrolysis—the destruction of tissue with the negative pole of a galvanic (direct) current. The destruction is due to electrolysis, which causes the collection of caustic or destructive chemicals around the needle. Electrolysis is used extensively in dermatologic practice.

For medical purposes the same current is applied with large electrodes, the dispersive indifferent electrode being held in the hand or strapped to some convenient part, while the active electrode is held against the part to be treated or is kept in motion over the part. It is averred that with the negative pole there is vasodilatation and a softening effect on new formed tissue (scars), while with the positive pole there is vasoconstriction and hardening. Medically, the galvanic current is used often in connection with some ion, especially the ions of chlorine, zinc, copper, carbon, silver, histamine and acetyl-beta-methylcholine chloride. It is said that these and other ions can be forced into the skin by the galvanic current (common ion transfer). Common ion transfer has not been very successful in dermatology.

CAUTERIZATION

Cauterization may be accomplished with chemicals or with heat. We are concerned here only with heat. The actual cautery (thermocautery) consists of a red hot or white hot object, usually a piece of wire or a pointed metallic instrument. The wire or metallic point may be heated in a flame; it may be kept constantly heated with a device such as the Pacquelin cautery; or it may be heated with electricity (electric cautery; galvanocautery).

The cautery was employed formerly in dermatology more than at present. It is used occasionally for the

destruction of small benign growths such as warts, small basal cell epitheliomas, small areas of leukoplakia, visible cutaneous capillaries (telangiectasia) and some of the small precancerous dermatoses; also for the treatment of hypertrophic rosacea, rhinophyma, and a few other conditions. Most dermatologists prefer the high-frequency current or some other method for these purposes. Some high-frequency machines supply current for the electric cautery, making it unnecessary to purchase additional apparatus for this purpose.

Focusing the sun's rays with a lens for the purpose of destroying certain skin lesions has been attempted, but the method has been used by very few physicians.

THERAPEUTIC REFRIGERATION

The term therapeutic refrigeration refers to the use of liquid air or solid carbon dioxide for therapeutic purposes. The skin can be superficially frozen with ethyl chloride, as every physician knows, but as a rule the therapeutic use of ethyl chloride is not included in the category of therapeutic refrigeration. Ethyl chloride has been used successfully in the treatment of larva migrans. It has been employed with indifferent success in dermatophytosis (ringworm) and scabies. Liquid air is a useful remedy but it is so difficult to obtain that it is rarely used. Solid carbon dioxide (CO_2 snow) has been a popular remedy among American dermatologists. Although it has been displaced to some extent by other remedies, it is still a useful therapeutic agent.

All that is necessary for the preparation of solid carbon dioxide is a tank or drum of carbon dioxide, which may be obtained from a dealer in any large city. Most dermatologists keep the drum mounted on the wall at an angle of 30 or 40 degrees. Snow may be collected in the following manner: A piece of ordinary blotting paper is rolled into a tube about 4 or 5 inches long. The circumference of this tube should be such that one end will fit snugly over the tank outlet. The blotting paper tube may be held in place with electricians' tape or with surgeon's adhesive tape (zinc oxide plaster). The free end of the tube is plugged with absorbent cotton. The tube is covered with a piece of chamois. The whole is now tightly bandaged with a wide bandage of

flannel. The valve is opened gradually until a crackling sound is heard, the tube swells, flakes of snow are seen and gas escapes at various points. The valve is left open for a minute while the crackling continues. This will produce pressure and the snow will be packed firmly. The valve is then closed and the tube removed. If properly done there will be a solid pencil of snow in the blotting paper tube. A perfect pencil of snow is so hard that it is difficult to cut with a sharp knife. The blotting paper is removed from one end, the remainder serving for insulation. The free end is shaped with a knife to a size and shape suitable for the particular application.

Various devices have been on the market for the convenient collection and preparation of solid carbon dioxide, most of which are seldom used. The Cryocautery of Lortat-Jacob and the Sparklet pocket CO_2 snow outfit are the two most common devices used in this country. In larger urban centers it is possible to obtain solid carbon dioxide from merchants who sell ice cream in the so-called dry packs (dry ice).

Solid carbon dioxide has a temperature of –79° C. When a pencil of snow is held in contact with the normal skin for one or two seconds, with light pressure, there is a stinging sensation and the application is followed by erythema. Four or five seconds will evoke a blister. Ten or fifteen seconds causes superficial necrosis. Longer applications, from fifteen to forty-five seconds, will cause moderately deep and deep ulceration, respectively. The degree of pressure makes a great difference in the result. A few seconds with heavy pressure is more effective than double the time with very light pressure. The result depends partly on the character of tissue treated. For instance, a verrucous lesion will tolerate considerably more treatment than will normal skin, as also will hyperkeratotic and acanthotic lesions.

Refrigeration, when applied to many conditions, results in a scar; but the scar is always soft, pliable and of excellent cosmetic or esthetic quality. Hypertrophic scars and keloids subsequent to refrigeration are rare. When applied to warts there is very little pain. When applied to other conditions, such as nevi, the pain is quite severe during the treatment and there is con-

siderable aching and throbbing for several hours. It is customary not to use any form of anesthesia.

Formerly, solid carbon dioxide was used as a treatment for a great variety of skin conditions. In this country it is now used mostly for certain nevi, for warts, and occasionally for telangiectasia and lupus erythematosus.

BALNEOTHERAPY

Medicated baths and wet dressings, especially the latter, are used extensively by all dermatologists. Wet dressings are employed mostly for acute inflammations of the skin, vesicular and pustular eruptions, and exudative surfaces. Distilled water is the vehicle that may contain any one of a large number of chemicals in high dilution—potassium permanganate, boric acid, aluminum acetate, metaphen, lead acetate, or silver nitrate.

Compresses and poultices are used to supply moisture, heat and medication. Hot poultices, so popular formerly, have been displaced to a large extent by medical diathermy and radiant heat.

The diseases and conditions for which wet dressings are used mostly are boils, carbuncles, wounds, erysipelas, cellulitis, infections, the various types of acute eczema, impetigo and folliculitis.

Medicated baths, while not particularly efficacious, are used for subacute and chronic eczema, ichthyosis, pruritus, urticaria, pemphigus and other diseases. Bran, oatmeal and starch are employed for soothing baths.

The so-called antipruritic baths are made by adding 8 or 10 ounces of sodium bicarbonate or magnesium sulphate to the water. Various pine products are on the market, also tar and sulphur preparations, for the bath. Sea water or sea salt is often used.

The continuous bath is used mostly for severe cases of pemphigus, when the greater part of the body is covered with bullae, crusts, erosions and vegetations. It is customary to add about 10 grains of potassium permanganate to the ordinary 40 gallon bath.

Other forms of hydrotherapy are employed very little in dermatology. Many dermatoses disappear during a vacation at some spa, but dermatologists are generally agreed that improvement, when it occurs, is due to changed environment, rest or psychology.

MASSAGE, POSTURE, STRAPPING

In dermatology, massage is employed as an adjuvant in a few diseases. Massage of the scalp is used for local circulatory benefit in the various types of alopecia. Massage is a recognized treatment for keloids, keloidal bands, hypertrophic scars and adherent, hard, contracted cicatrices. It is employed, as a rule, as an adjuvant to other treatment, such as x-rays, radium or galvanism. The best results seem to be obtained by a rapid kneading motion.

Massage is one of the best treatments for scleroderma. The motions consist of gentle kneading and stroking. Massage is used a great deal in cosmetology —for wrinkles, sagging or paleness. Its use in dermatology is limited. It is customary, when employing massage for these conditions, to apply some form of grease. Cocoa butter (oil of theobroma) appears to be the most popular substance for this purpose. Cold cream containing a little heavy liquid petrolatum, petrolatum or hydrous wool fat is used often in place of the cocoa butter.

Occasionally, massage is indicated for chronic eczema of the extremities, or for any condition associated with congestion and stasis. Often it is combined with special posture as, for instance, elevation of the legs or arms. These measures are used for such disorders as Raynaud's disease and chronic ulcers.

Cutaneous stasis may at times be lessened, and indolent ulcers, especially those having an infiltrated or indurated margin, may be benefited by strapping with adhesive plaster or the wearing of some support for the local circulation, such as elastic stockings or bandages that possess elasticity.

It is advisable, when treating chronic cutaneous conditions of the legs associated with varicose veins, to instruct the patient never to stand still for more than a few seconds. He may take a prescribed amount of walking because intermittent muscular contraction is thought to favor circulation, whereas the continuous tension produced by standing may interfere with circulation.

DISEASES AMENABLE TO PHYSICAL AGENTS

Verruca (wart).—There is a large variety of verrucae, most of which are only of cosmetic importance. The physician should be certain of the diag-

nosis; otherwise a benign lesion might be mistaken for a dangerous one. Because of their benign nature and cosmetic importance, it is often essential to select a method that will destroy the wart without leaving a scar. Not infrequently, one encounters a scar that is more disfiguring than the original, harmless lesion.

Verruca Vulgaris.—Surgical Diathermy: Very small lesions, and even larger ones, will at times disappear subsequent to mild electrodesiccation of the surface of the wart. If the treatment is successful, the wart disappears in two or three weeks without leaving a scar. It is more efficacious to make one or several insertions of the needle, permitting the current to act for a fraction of a second.

The common wart is occasionally exceedingly stubborn. Treatment as already outlined will in such instances fail to cure, or the lesion may disappear and recur. Such lesions can be cured usually by thorough dehydration or by coagulation. If the wart after such treatment is left in situ, it may remain dry and drop off in two or three weeks; but it is more likely to slough under the crust and cause considerable inflammation. For this reason it is preferable to enucleate the dried lesion with scissors or curet. The after-treatment is that of an ordinary wound, and the ultimate result is usually a scar, which occasionally is hypertrophic.

Refrigeration and Other Physical Agents: Solid carbon dioxide offers a useful and often satisfactory treatment for the common wart. A pencil of hard snow, with an end which has been trimmed to proper shape and size, is pressed firmly against the surface of the lesion until the area turns white. When successful, the wart disappears in about three weeks. Usually there is no scar.

Common warts can be destroyed with electrolysis and with the actual cautery, but these agents are seldom used for this purpose.

Verruca Plana.—The juvenile flat wart (verruca plana juvenilis) does not yield particularly well to electrodesiccation, and destruction by this method is very likely to leave objectionable scars. There are better methods of treatment.

Small discrete flat warts in adults can be destroyed with exceedingly superficial electrodesiccation, skilfully

applied electrolysis, or a very light application of solid carbon dioxide without leaving a scar.

Verruca Plantaris.—Electrodesiccation is an excellent method of destroying these troublesome lesions. The lesion is first thoroughly desiccated by sparks applied from a needle to its entire surface for a minute or two. The wart may then be shelled out and the base and edge of the wound electrodesiccated. Thereafter, the patient has the discomfort of an ordinary wound which usually is much less trying than the wart. The after-care is that of any ordinary wound. The wound will heal in from one week to three or four weeks, depending on its size and depth.

Verruca Acuminata (condyloma acuminatum).—Very small, discrete warts may be destroyed with superficial electrodesiccation without local anesthesia. Otherwise it is necessary to desensitize the involved area, electrodesiccate thoroughly, remove the desiccated lesions with a curet, and then lightly desiccate the wound. The results are excellent.

Venereal warts may be destroyed, also, especially when small and isolated, with solid carbon dioxide, electrolysis and the actual cautery, but these agents are not so efficacious as is electrodesiccation.

Miscellaneous Warts.—Scalp warts may be of the common type, flat type, and so on. Often they are of the digitate variety. Any scalp wart can be quickly destroyed with electrodesiccation by means of the technic given for verruca vulgaris. When properly applied, there is no danger of permanent alopecia.

Warts of several varieties occur on the mucous membranes of the lips, tongue, cheeks, penis, vulva and the mucocutaneous juncture of the eyelids. Electrodesiccation is a suitable treatment for warts in these locations. Lesions on the eyelid should be very superficially desiccated in an attempt to prevent scarring and loss of eyelashes.

The bearded region of the adult male and the neck of women are favorite locations for digitate and especially filiform warts. Digitate warts may be lightly desiccated and removed with a curet, and the base lightly desiccated. If carefully done, there will be either an almost imperceptible scar or none at all.

Filiform warts may be single but often they are numerous—at times a hundred or more. Such lesions

can be destroyed by an instantaneous application of a very mild electrodesiccation current to the base of the wart. They drop off in about a week and when carefully done there is no permanent disfigurement.

Any of these miscellaneous warts can be destroyed with solid carbon dioxide, electrolysis or the actual cautery. Skilfully applied, electrolysis will remove filiform warts without the slightest scar. Judicious applications of solid carbon dioxide are efficacious for filiform warts of the skin and mucous membranes and as a rule there is no scarring. The actual cautery is seldom employed for this purpose.

Keratoses.—There are a number of types of keratoses and it is important to differentiate between them because the potentialities differ with the type. They are included among the so-called precancerous dermatoses, but some of them are almost free of danger while others are extremely dangerous. It is also important not to confuse a keratosis with an early stage of epithelioma, or sarcoma, or with tuberculosis, psoriasis, and other diseases.

Keratosis Seborrheica: This is the most common type of keratosis. While classified among the so-called precancerous dermatoses, the seborrheic keratosis is not very dangerous. It may give rise to basal cell epithelioma. For the sake of appearance and as a prevention against basal cell epithelioma, it is often desirable to destroy these lesions; but it is not always necessary nor even advisable to do so.

The physician should use judgment in selecting the treatment best suited for the individual case. Electrodesiccation is an excellent therapeutic method for this purpose, but there are better methods for selected cases. It is, for example, poor judgment to replace a small, superficial, almost benign seborrheic keratosis on the face of a society woman with an objectionable scar.

When a slight scar is of no importance, the surface of the lesion and a little normal skin around the periphery of the lesion may be rather thoroughly desiccated. If there is definite infiltration under the horny layer, the area may be curetted after thorough superficial desiccation and the resulting wound again electrodesiccated. Such treatment usually leaves a mild, permanent scar.

Electrolysis, solid carbon dioxide and the actual cautery are used by some dermatologists for the

destruction of seborrheic keratoses. If expertly applied these agents give satisfactory results, but they are not popular for this purpose.

Keratosis Senilis: The senile keratosis should be taken seriously. It is one of the forerunners of epidermoid cancer. These lesions are especially dangerous when occurring on the mucous surface of the lips. In this location they should be radically destroyed as soon as diagnosis is established.

Of the various physical agents (excepting radium and x-rays) electrodesiccation is the best one for this purpose. The lesion and a little normal skin around the lesion is thoroughly desiccated by surface application of the monoterminal current. The dehydrated tissue is then removed with curet or scissors and the wound desiccated with the same current.

If there is any infiltration; that is, if the lesion is thick or elevated, an early stage of prickle cell epithelioma should be suspected. It is now the physician's responsibility to make the diagnosis and decide on the best method of treatment. If properly done, surgical diathermy is one of the best treatments, either alone or combined with x-rays; but radium and especially scalpel surgery are more suitable for selected cases. Other physical agents should not be used.

So far as concerns surgical diathermy, one may coagulate, desiccate or excise with the cutting current, depending on conditions. It is customary first to establish a circle of coagulation a few millimeters beyond the lesion and extending down to the muscle. Next, the lesion is thoroughly desiccated or coagulated to the same depth. The destroyed tissue is then removed with cutting current, scalpel, curet or scissors and the wound dehydrated with electrodesiccation. Some physicians prefer to excise the lesion with the cutting current and use the material for microscopic examination.

Miscellaneous Keratoses: Arsenical keratoses resemble senile keratoses. Not infrequently they give rise to cancer, either basal cell or prickle cell, usually the latter. Numerous, closely crowded, deep lesions on the palms and the soles are usually treated expectantly and the patient kept under observation. Discrete lesions are treated in the same way as senile keratoses.

X-ray and radium keratoses occur on the so-called x-ray or radium skin. A fairly large percentage of

these lesions give rise to epithelioma, usually of the epidermoid type. The tissue in which this type of keratosis develops, because of degeneration and sclerosis, is often unfavorable soil for any therapeutic agent. Small, discrete, superficial keratoses of this type may be destroyed with various physical agents, but the most popular method is electrodesiccation.

The keratoses of xeroderma pigmentosum resemble the senile variety and sooner or later give rise to epithelioma, which, however, is often of the basal cell type. The treatment is the same as that outlined for seborrheic keratosis.

Leukoplakia.—Leukoplakia is one of the forerunners of epidermoid cancer. For this reason every case should be kept under observation indefinitely. Small lesions may be destroyed with the actual cautery or with electrodesiccation. When the cautery or electrodesiccation is used, care should be taken to destroy the entire thickness of the mucous membrane, and the destruction should extend beyond the periphery of the patch.

Many cases of leukoplakia are widespread. In such instances it is preferable to inspect the mouth every three months. If, at any time, one portion of the leukoplakia shows persistent activity—erosion, fissure, ulceration, warty excrescences—that particular portion should be destroyed.

Kraurosis Vulvae: Areas of leukoplakia, warty growths or fissures occurring in this disorder should be handled as described under leukoplakia.

Tuberculosis of the Skin.—Lupus Vulgaris: Discrete apple-jelly nodules can be destroyed with the actual cautery and with electrolysis, but perhaps the best destructive physical agent for this purpose is electrodesiccation. Superficial nodules can be dehydrated by applying a strong current to the surface for half a minute or longer, or the needle may be inserted into the nodule. Large patches of lupus vulgaris can at times be cured in this manner. Occasionally it is advisable to desiccate or coagulate the entire patch.

Tuberculosis Verrucosa Cutis (verruca necrogenica; warty tuberculosis of the skin): Small lesions of this form of true tuberculosis of the skin can be permanently destroyed with electrodesiccation. Large patches are difficult to cure. It is necessary, as a rule,

to desiccate or coagulate very thoroughly, remove the destroyed tissue and then electrodesiccate again.

Sarcoid: There are two recognized types of sarcoid —the deep (Darier-Roussy) and the superficial (Boeck). Small lesions of the latter type can be destroyed satisfactorily with electrodesiccation. Other physical agents, with the exception of x-rays and radium, are not very efficacious.

Lupus Erythematosus: Before the advent of intravenous gold therapy, solid carbon dioxide was perhaps the best treatment for the fixed or discoid type of lupus erythematosus. Even now, it is used occasionally as an adjuvant for very thick discoid patches. It is never used for the disseminate type.

Miscellaneous Types of Cutaneous Tuberculosis: Granuloma annulare is treated occasionally with destructive physical agents, but there are much better methods of treatment. The individual nodules of lupus miliaris disseminatus faciei and allied conditions can be destroyed with electrodesiccation, as in lupus vulgaris, but such treatment is seldom employed because the lesions often disappear spontaneously and because they are very amenable to x-ray treatment.

There are a number of clinical entities falling in the tuberculosis group that will not be mentioned here because they are seldom if ever treated with the agents being discussed in this article. Some types of orificial tuberculosis—circumscribed lesions of the tongue, mucous membrane of the cheek, near the meatus, or in the anal region—can be successfully managed with the actual cautery or with electrodesiccation.

Nevi.—Birthmarks are divided into types. Physical therapy is indicated for a number of types, but as one agent produces a better result in one variety than in another, it is advisable to mention each type of nevus separately.

Vascular Nevi: These are common and may be conveniently divided into four varieties: nevus araneus (spider nevus); nevus flammeus (port-wine mark) and angioma, the latter being subdivided into the strawberry mark and the cavernous angioma. Scientifically they all are classed under angioma or hemangioma.

Nevus Araneus: These lesions present a dark red center which varies in size from a tiny dot to the head of a pin. From this center, somewhat tortuous, dilated

capillaries extend outward for a distance of perhaps half an inch. The best treatment for the spider nevus is electrolysis. All that is necessary is to puncture the central dark spot with the point of the needle. There should be no scar.

Nevus Flammeus: Unfortunately, there is no satisfactory treatment for port-wine marks. It is almost hopeless to attempt eradication of an extensive lesion; one, for instance, that involves the arm, forearm and hand. Repeated strong applications of solid carbon dioxide will remove small lesions, but, of course, such treatment leaves a scar. Electrodesiccation is less satisfactory than refrigeration, and cicatrization is more pronounced.

Strawberry Mark: These lesions can be destroyed in various ways—refrigeration, electrodesiccation and excision—but by far the best results are obtained with radium. Any treatment other than with radium leaves a scar.

Cavernous Angioma: Unlike the other vascular nevi, these lesions are deep. Here, too, the therapeutic results are better with radium than with any other agent, provided the treatment is administered during infancy or very early childhood. Other physical agents are useful for older patients or for lesions that do not yield to radium. All successful physical therapeutic methods, other than radium, cause ulceration and scars. Small, comparatively superficial lesions can be destroyed with solid carbon dioxide. The resulting scar is of excellent quality. Electrodesiccation and electrocoagulation have been used successfully for small lesions. Multiple insertions of the needle at intervals of a few millimeters are usually necessary.

Senile Angioma: This is a vernacular term for angioma developing during adult life and old age. These lesions, when small, may be destroyed easily with superficial electrodesiccation. Angiokeratomas may be destroyed in the same manner.

Lymphangioma: There is no satisfactory treatment for the deep type—injections, surgery and surgical diathermy have been used with some success. The superficial type can be destroyed, if so desired, with solid carbon dioxide or electrodesiccation.

Pigmented Nevi: Lesions falling under the head of nevus pigmentosus range from those having little if any

importance to those that are very dangerous. In order to select the best treatment for a given lesion, to decide for or against treatment, the physician must have considerable knowledge relative to the therapeutic methods and the various types of nevi. It is, in fact, so important to be certain of the potentialities of a given pigmented mole that the family physician is foolish to accept the responsibility of treatment without a consultation. The classification used here is not conventional; it is for convenience.

Common Mole: The common mole, a lesion that is small, smooth, shiny, more or less elevated, of normal skin color or of various shades of brown, and which usually contains a few coarse hairs, is not considered a dangerous lesion unless subjected to frequent traumatism over a period of many years. The selection of proper treatment requires discriminating judgment. When only of cosmetic importance, moles may be ignored or they can be removed with electrolysis with almost no scarring. When potentially dangerous because of repeated traumatism, they may be excised or destroyed with electrocoagulation. When such moles are very dark, especially blue-black, they should be let alone or radically destroyed.

Mouse-Skin Moles: These moles are dark brown, more or less elevated, thick and sharply outlined and contain, as a rule, a large quantity of rather fine hair. The appearance is somewhat that of mouse skin. They are not considered very dangerous. Excellent results have been obtained with solid carbon dioxide, although several strong applications may be necessary. Electrodesiccation is also a good remedy for small lesions.

Flat Pigmented Nevi: These nevi consist clinically of a sharply outlined area of pigment which may be of any size or shape. The color is important. When of a light brown they are not considered to be dangerous and may be destroyed with solid carbon dioxide. Black, slate gray, brownish-black and especially bluish-black moles of this type, without hair, are considered to be potentially dangerous. Occasionally, sarcoma develops in such lesions, especially when they have been traumatized. While the majority of such lesions never change to cancer, they are a menace and therefore it seems preferable to destroy them—but if they are treated at

all it is essential that every cell be destroyed. This necessitates surgical excision or some form of surgical diathermy. The destruction should extend well beyond the visible margin of the lesion and down to the underlying muscle.

Miscellaneous Nevi: Nevus unius lateralis, or linear birthmark, may be of almost any of the types mentioned in this article. Treatment depends on the type. The verrucous or warty nevus is difficult to treat successfully. Solid carbon dioxide and electrodesiccation are successful in some cases.

The cerebriform nevus must be considered potentially dangerous because it occasionally gives rise to sarcoma. Any treatment that fails to destroy every cell is contraindicated—solid carbon dioxide; electrolysis; light electrodesiccation. Surgery or radical surgical diathermy are the best methods if the lesion is to be treated at all.

Papillary nevi can be destroyed with solid carbon dioxide or with electrodesiccation.

Hairy nevi (nevus pilosus) may occur alone or in combination with pigmented moles (nevus pigmentosus et pilosus). When the hair is dark and coarse, it may be removed with electrolysis. There is no satisfactory method for the permanent removal of lanugo hair.

Miscellaneous Benign Growths and Hypertrophies.—Keloid, Hypertrophic Scar and Cicatrix: A keloid denotes idiosyncrasy. The removal of a keloid by any method that causes traumatism (surgery, any surgical diathermy method, solid carbon dioxide, electrolysis) is likely to be followed by another keloid that is larger than the original one. Combined with the proper use of x-rays or radium, the surgical methods are invaluable for selected cases. Thick keloids may be removed to the level of the normal skin with the cutting current and the resulting wound treated with x-rays.

A hypertrophic scar does not necessarily indicate idiosyncrasy. It may be due to tension. With the exception of x-rays and radium, physical agents are not of much value. Mild cases may possibly be improved by frequent application of the galvanic current over a period of several weeks or months.

Massage is of some value for the treatment of hypertrophic scar tissue. A member of the family can be shown how to carry out the massage. Treatment

should be given about three times weekly for several months.

Dermatitis Papillaris Capillitii (acne keloid): In this disorder, when the keloidal element is too massive for x-rays alone, the growth may be removed to the level of the skin with the cutting current (a loop electrode usually being used) and the wound treated with x-rays.

Chondrodermatitis Nodularis Chronica Helicis: Lesions of this disorder can be removed with the cutting current or destroyed with electrodesiccation.

Clavus: Corns, either hard or soft, when failing to respond to conventional dermatologic therapy, can be excised with the cutting current or they can be destroyed with electrodesiccation.

Fibroma: Small, pedunculated fibromas, so common on the neck of middle-aged and elderly women, can be destroyed with electrodesiccation without the slightest scar if carefully done.

Granuloma Pyogenicum: Electrodesiccation offers a suitable method for the destruction of these lesions. Granuloma pyogenicum may resemble a rapidly growing sarcoma. Naturally, the differentiation is important.

Xanthoma: Small lesions of xanthoma tuberosum multiplex may be destroyed with electrodesiccation or with solid carbon dioxide, preferably the former. It is advisable not to treat the individual lesions of xanthoma diabeticorum at least until conventional remedies have been tried. Xanthoma palpebrarum (xanthelasma) responds better to trichloracetic acid than to any of the physical therapeutic remedies.

Adenoma Sebaceum: The papules of this disorder can be destroyed with very mild electrodesiccation, with mild applications of solid carbon dioxide or with electrolysis. Scars should be avoided.

Sebaceous Adenoma: Adenomas of the sebaceous glands may be single or multiple. They may be destroyed either with electrolysis or with electrodesiccation.

Multiple Benign Cystic Epithelioma (tricho-epithelioma; epithelioma adenoides cysticum; syringocystoma): These small usually numerous papules or nodules can be removed with cautiously applied electrolysis or electrodesiccation, but there is likely to be some scarring.

Cornu Cutaneum: Cutaneous horns are included among the precancerous dermatoses. They should be destroyed by thorough electrodesiccation under local anesthesia.

Scleroderma: Massage with cocoa butter is a useful treatment for this disease. A few cases have improved during a course of treatment consisting of applying medical diathermy to the spine and roots of the spinal nerves.

Cysts.—Mucous retention cysts of the lower lip can be destroyed with monoterminal or biterminal surgical diathermy. If not completely destroyed or removed, they will recur. Sebaceous cysts, when small, can be destroyed with surgical diathermy in the following manner (Wyeth): A small opening is made into the cyst with the cutting current. The electrodesiccation needle is inserted through this opening and the entire cyst wall is destroyed with the monoterminal current. Very small lesions may be destroyed with electrolysis.

Hydrocystomas are likely to disappear as a result of simple puncture. If not, they can be destroyed with electrodesiccation.

Furunculus; Carbunculus.—Boils, when detected very early, can be aborted at times by inserting the needle into the central follicle and applying a mild monoterminal high-frequency current for a fraction of a second. Medical diathermy is useful for both boils and carbuncles.

Lichen Planus.—Juan Jose Mestre of Havana has reported excellent results in lichen planus by applying medical diathermy to the cervical and upper dorsal spinal regions. The method has not yet been evaluated.

Rosacea and Rhinophyma.—Often in rosacea there are a few or many dilated visible cutaneous vessels. Destruction of such vessels lessens congestion, improves the appearance, and may make the rosacea more amenable to treatment. Small vessels can be destroyed with electrolysis, the larger ones with electrodesiccation.

Hypertrophic rosacea can be greatly improved with electrolysis or electrodesiccation, especially the latter.

The lobules of rhinophyma can be removed with the cutting current and the resulting wound heavily desiccated. Several excellent results have been obtained

in this manner. Loop electrodes are convenient for the purpose.

Telangiectasia.—Dilated, visible cutaneous capillaries occur in association with a number of the dermatoses —rosacea, sequel to x-ray and radium treatment, keloids, hypertrophic scars; lupus erythematosus, and so on. They occur, also, in association with a florid complexion.

When the vessels are small and not too numerous they may be occluded with electrolysis and if this is carefully done there will be little or no scarring. Electrodesiccation is more rapid, but objectionable scarring is likely to result.

Hypertrichosis (hirsuties).—Current from the secondary winding of the high-frequency transformer has been recommended for the permanent removal of superfluous hair. Thus far, however, the results have not been satisfactory. Practically, the only way in which superfluous hair can be removed permanently and safely is with electrolysis. The method requires patience, skill and care. Space does not permit a detailed discussion of technic, especially as it is given in many textbooks on dermatology.

Malignant Neoplasms.—In the treatment of cutaneous cancer, in order to obtain the best results, the physician should possess adequate diagnostic skill and he should be proficient in the use of the various recognized methods of treatment. Such knowledge favors correct diagnosis and selection of a method or combination of methods best suited to the particular case. Space permits no more than an exceedingly brief mention of this important and highly specialized phase of the subject.

Basal Cell Epithelioma: It is possible to cure permanently the majority of epitheliomas of this type with expertly applied electrocoagulation. Solid carbon dioxide, cauterization and electrolysis are not nearly so efficacious and should seldom be used, if ever, for the treatment of this condition.

Squamous Cell Epithelioma: When recognized early, before it has become invasive and before metastasis has occurred, this type of epithelioma can be cured with expertly applied electrocoagulation, or the lesion may be excised with the cutting current. The same state-

ment applies to melanomas and malignant sarcomas. Solid carbon dioxide, cauterization and electrolysis are contraindicated. In general, when dealing with cutaneous malignant neoplasms, and before treatment is instituted, it is advisable for the physician to consult a colleague who has had extensive experience in the diagnosis and therapy of cancer.

PHYSICAL THERAPY DEPARTMENTS IN HOSPITALS WITH FIFTY OR MORE BEDS

COUNCIL ARTICLE

The increasing recognition of the value of physical therapy in conjunction with medicine and surgery has led to a growing demand for information on suitable plans for departments of physical therapy. The following outline of minimum requirements for such departments is suggested with this in view.

Each hospital has certain problems common to all as well as its own individual ones. In any given instance, the type of hospital, the types of cases treated, the number of nonpaying as compared to paying patients, and, most important of all, the attitude of the general staff toward physical therapy will determine the size of the department. If the staff members are not aware of the good results that may be obtained through the use of physical therapeutic measures, such as the important shortening of convalescent periods and the more complete restoration of function to injured joints, muscles, tendons and nerves, they will not refer cases to the department which may profit by these treatments but will use it as a dumping ground for patients with chronic disabilities.

Any therapeutic measure to be effective must be prescribed with a definite objective in view. Ill advised prescription of physical therapeutic agents by the director of the department will discourage both the patients and the referring physicians. Their consequent loss of confidence will be reflected in the general attitude toward the department. Since the success and growth of the department depend on satisfying these two parties, it is most essential that the staff be alive to the possibilities inherent in physical therapy so that its intelligent cooperation will be assured. Without this, the department will not become an integral part of the institution.

Once the cooperation of the staff has been secured, the next step in planning the department lies in con-

sidering the chief function for which the hospital was planned, since this will determine the types of cases to be treated. Hospitals that specialize need equipment particularly adapted to themselves; for example, institutions for mental and nervous cases utilize hydrotherapy extensively, while hospitals for tuberculous and pediatric cases may concentrate on ultraviolet therapy. In general hospitals, especially those serving a high percentage of orthopedic and traumatic cases, there is the greatest need for well trained technicians able to give massage, muscle training and other types of exercise. A limited amount of apparatus is needed for heat therapy, hydrotherapy (principally pools for underwater exercise), occupational therapy and muscle reeducation exercises.

To determine further requirements for any particular hospital, its statistics should be studied to find the predominant types of cases treated, the daily average of bed patients who may need physical therapy, the possible number of outpatients and the financial outlay which the hospital is prepared to make. Given time, a properly managed department will become a decided asset but, as in any undertaking, this must be shown to the management to be believed. A moderate investment will be enough to start with. Later the department may be built up as its importance is felt. From statistics gathered as aforementioned, an estimate may be made of the probable number of treatments to be given and types of cases that will be most frequently encountered and benefited.

With these figures in hand, the next move will be to choose the right personnel. All the ingenuity and planning that go into creating the mechanical set-up will be wasted without a properly trained director in control. This physician, in addition to ground work in medicine and surgery, should have taken a postgraduate course in physical therapy. Although apparatus-therapy is only a small part of physical therapy, it will be necessary for the director to understand the physical principles involved in the construction of the various devices as well as the clinical applications of these different units. Such a background will enable him to prescribe physical measures effectively.

Smaller hospitals may not require the services of such a director. If a roentgenologist who has had some

training in physical therapy is available, the physical therapy department may be combined with his. Where a man with this type of training is not available, obviously some member of the staff must acquire sufficient knowledge of physical therapy to supervise the department.

Larger hospitals can afford to employ a part-time director who divides his time between several institutions. In the largest hospitals the director may have to spend his entire time in the department directing or administering treatments and examining the patients at frequent intervals to make certain they are gaining ground. If and when no progress is being made, this first-hand knowledge serves as a check to prevent clogging the channels with "treatment habit" patients.

Quite often the referring physician will prescribe his own treatments. This does not minimize the responsibility of the director of the department. If after examining the patient, he feels that the prescribed therapeutic measures are not indicated, he is at liberty to discuss this with the referring physician and suggest treatment which he feels is applicable.

The guiding hand of the director will count for nothing without the proper technical personnel. Choice of the right technician will ensure correct application of the prescribed treatments. The head technician of a department should be a graduate of an approved school for physical therapy technicians and be registered with the American Registry for Physical Therapy Technicians. The Council on Medical Education and Hospitals of the American Medical Association has published a list of approved schools of this type.[1] As prerequisite for admission to these schools the candidate has had to satisfy one of the following requirements:

(*a*) Two years of sixty semester hours of college, including courses in physics and biology.

(*b*) Graduation from an accredited school of nursing.

(*c*) Graduation from an accredited school of physical education.

The training itself consists of at least 1,200 hours of theory and practice, including 210 hours of applied anatomy. A technician with this training, although

1. J. A. M. A. **112**: 929 (March 11) 1939.

completely unequipped to diagnose cases, has gained sufficient knowledge of anatomy, physiology and pathology to understand the theory underlying the prescribed treatment. Such background cannot be acquired in one-week courses in which a nurse is shown how to operate a few electrical machines. Nor can the run-of-the-mill masseur give adequate physical treatments. The number of treatments which one technician can give in a day will depend on the type of cases treated. On an average, adequate treatment cannot be given to more than from sixteen to twenty patients a day. If the aforementioned type of personnel is not available to the hospital, considerations for starting a physical therapy department may as well be dropped until such personnel is available.

When the cooperation of the staff is assured and the proper personnel is at hand, it is time to decide on a location for the department. Unfortunately, the ideal arrangement of rooms cannot be added to old hospitals in which all available space is probably utilized. Consequently, many departments have been placed in basements. It seems timely to advise against this.

The best location is on the first or ground floor. This will enable outpatients to receive treatment without going through the hospital corridors. Many of these outpatients are crippled and unable to ascend stairs. It is particularly important to have the rooms well ventilated and well lighted, because fresh air is vital where exercises are to be given.

Temperature in the rooms is apt to be higher than outside owing to the presence of heat-producing machines. Consequently the patient may not be even moderately comfortable unless there is cross-ventilation. In still air, excess heat is dissipated by the patient chiefly in the form of perspiration, and very inefficiently in that form. Stagnant air next to the body becomes saturated and then perspiration does not evaporate until this layer moves off by diffusion. With moderate air motion, on the other hand, the patient will maintain his temperature equilibrium by the loss of heat through evaporation, convection and radiation. Air motion lowers the humidity in the room, thus increasing the patient's comfort.

Other considerations determining the location of the department follow. Proximity to elevators is essential

since it is more convenient to bring patients to the department than to treat them in their rooms. Also it is easier for the technician to take apparatus to the patient's room or surgical floor when necessary. The relationship to the various clinics and the x-ray department is important. Availability of water supply, sewers, toilets, electric outlets and floor exits must also be taken into account.

If a new department is to be built, the architect should consult with the director when making plans. The two main types of departments are as follows: (1) a single large room; (2) separate rooms for each therapeutic measure. Innumerable variations lie between.

A large treatment room may be used in general hospitals or in a large free clinic. Here a certain amount of privacy is achieved by dividing the large room into a number of cubicles, either by means of sheets suspended from a 7 foot level or by steel, marble, beaverboard or other types of partitions. See treatment cubicle room on hospital plan (fig. 1), in which this has been done successfully. The cubicles should measure at least 6 by 8 feet. Larger ones are preferable. If private patients are to be treated in general hospitals, several adjoining rooms may be utilized for heat therapy and massage, for hydrotherapy, for muscle reeducation exercises, for ultraviolet treatments and for applications of high frequency currents (fig. 2). In a 300 bed hospital with a department, such as seen in figure 2, many private patients receive treatments in their own rooms. In such cases the department proper does not have to be as large as that in a general hospital treating a preponderance of clinic patients.

Linoleum or some rubber composition makes a soft floor covering. The technician is on her feet all day. Consequently her efficiency is decidedly lowered by foot ailments. A hydrotherapy department needs tile or concrete floors. There may be a pool in this department for underwater exercises. Owing to the weight of the pool, this section must be placed on the ground or basement floor regardless of the location of the rest of the physical therapy department.

The plans for the wiring and placing of apparatus should be drawn with a view to the future, rather than the immediate, needs of the department. It is far less

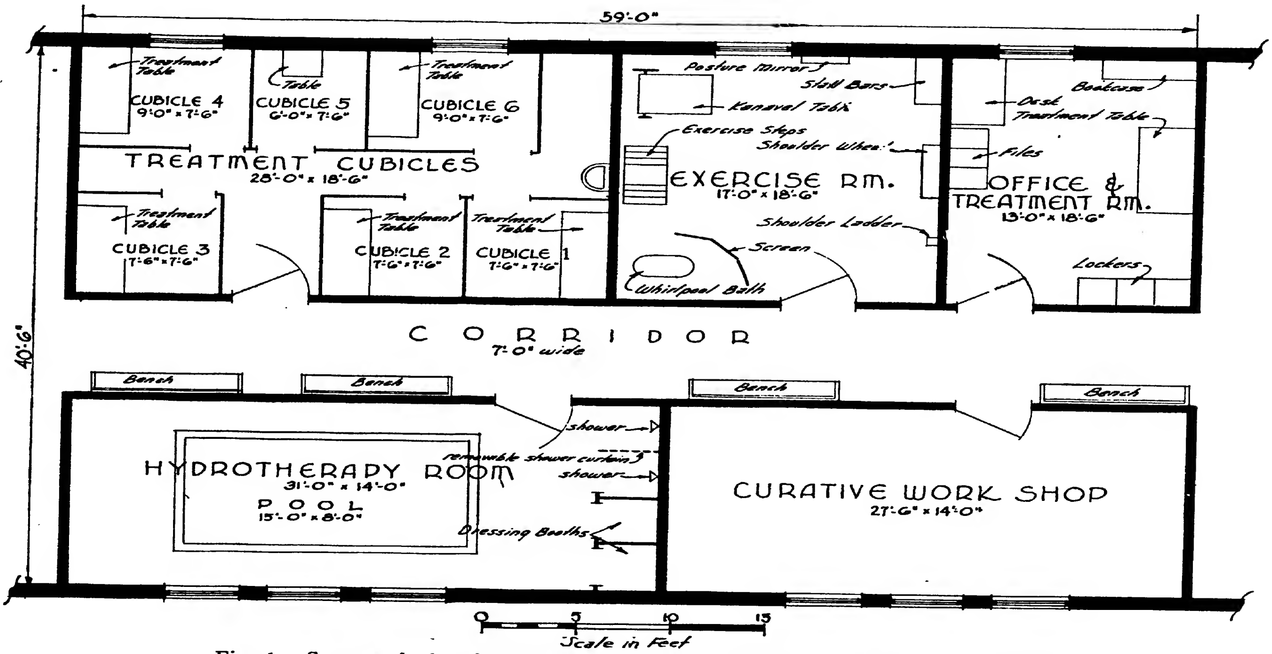

Fig. 1.—Suggested plan for a physical therapy department in a 250 bed hospital.

expensive to have too many outlets in the beginning than to tear up the walls for rewiring later. The plugs connecting the machines to the wall receptacles should be designed to fit only one outlet so that no mistakes, such as blown fuses, will result. Polarity plugs may be used with direct current apparatus to advantage. The

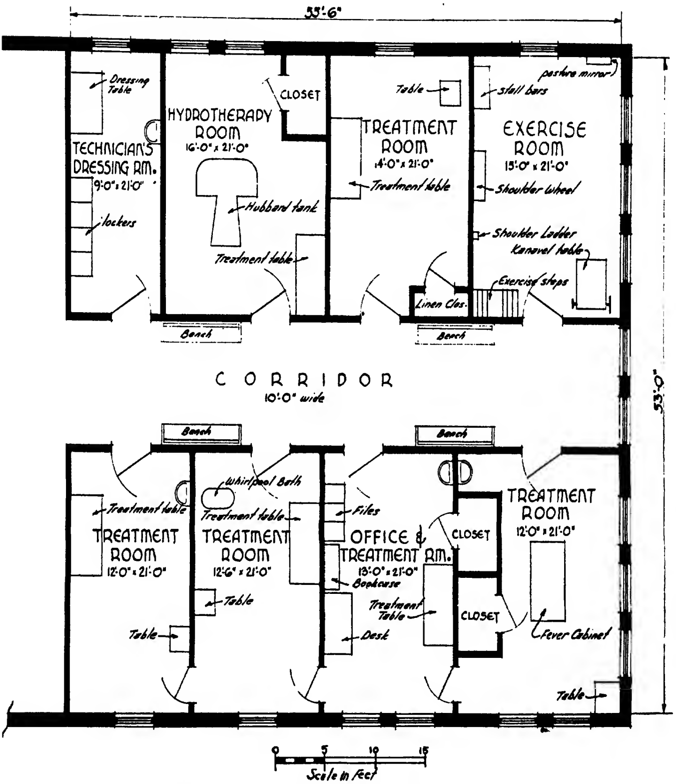

Fig. 2.—Suggested plan for a physical therapy department in a 300 bed hospital.

outlet plugs should be placed from 3 to 4 feet from the floor level so that they may be reached without stooping. This also facilitates the movement of apparatus.

Mock stated that 90 per cent of physical therapy in general hospitals consists of common sense and intelligent handwork. Elaborate apparatus and machine therapy do not make a physical therapy department. The

director is advised to keep this truism in mind when outfitting a department. The physician in charge of the department must have a clear idea of the elementary physiologic reactions of the body to heat, light, water, electric current and exercise so that he may prescribe a particular measure for a given purpose.

Probably there will be relatively few patients needing physical therapy in the fifty bed hospital. If one of the staff physicians or the roentgenologist is trained to direct the use of physical measures, it may be possible to obtain a technician for part time service. A room approximately 24 by 30 feet may be set aside for this department. Partitions of wall board or other light material form the main walls of treatment cubicles. Curtains may be used for the front wall. Desk and other equipment is then conveniently located in the remaining space (fig. 3). It may not be possible to set a room aside for this department. If such is the case, only the simplest measures should be prescribed, preferably those which may be carried out in the patient's room.

Minimum requirements in equipment will consist of apparatus which can be made by the hospital carpenter and electrician, it being kept in mind that heat can be administered with wide success without much apparatus. The units decided on should be readily movable; i. e., on casters, or portable:

Two home-made bakers:[2] one for local applications (14½ inches high by 17 inches long by 14 inches wide, containing approximately four 60 watt bulbs); one for body applications (24 inches high by 30 inches long by 22 inches wide, containing approximately eight 60 watt bulbs).

One paraffin bath: 1¼ gallon double boiler; electric or gas stove; 8 pounds of paraffin.

One tank for underwater exercise.

Exercise apparatus (see fourth following paragraph for list and choose simpler ones at first).

If funds are available, the two following lamps may be used in place of bakers:

Tungsten 1,000 watt lamp (for "near infra-red," where deeper penetration over large body area is desired—from 10 to 30 mm., according to Coblentz).

2. Directions for making bakers may be secured from the Secretary of the Council on Physical Therapy, 535 North Dearborn Street, Chicago.

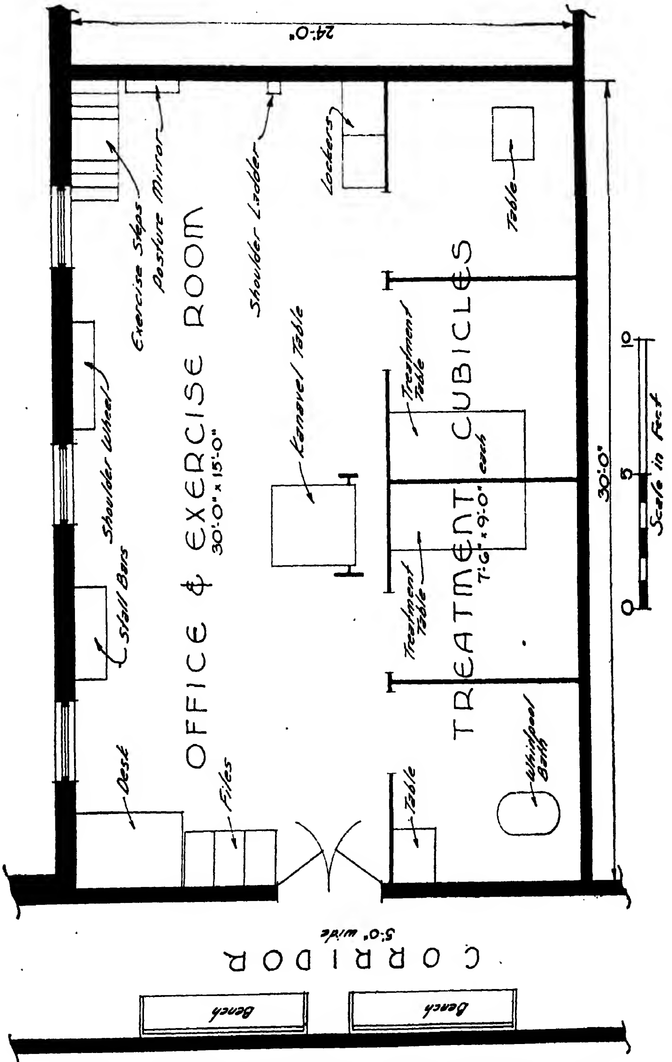

Fig. 3.—Suggested plan for a physical therapy department in a fifty bed hospital.

Small, nonluminous infra-red lamp (for "far infra-red" applications to local area, more superficial absorption—from 3 to 0.1 mm., according to Coblentz).

Other physical measures, such as massage, exercises, hot compresses and cold packs, may be supplied by the technician. If circumstances warrant, and only when warranted, the following equipment may be added:

One portable diathermy unit for medical and surgical use.
One ultraviolet mercury arc lamp.
One galvanic-sinusoidal outfit.

Hospitals with beds for 100 or more patients will probably need departments set aside for physical therapy (fig. 1). It is impossible to set arbitrary limits to the amount of equipment which a given hospital should require, since each has its own particular set-up. In any case the equipment should be purchased from a reliable manufacturer so that the servicing and replacement of parts will be assured. One of the functions of the Council on Physical Medicine of the American Medical Association is to set standards for acceptable devices and methods used in this field. It furnishes a list of accepted apparatus containing the names of manufacturers who have attempted to construct efficient and reliable equipment for the medical profession.

The following will give a rough idea of the appliances usually considered essential in the smaller departments in general hospitals of more than 100 beds:

Four tables (33 inches high by 78 inches long by 30 inches wide) can be made by the hospital carpenter. A shelf about 1 foot from the floor should be added to table for cold cream, powder and clothing. Tops of tables should be well padded and covered with nonconductive material.

One 1,000 watt tungsten lamp.

One or more small, luminous or nonluminous infra-red lamps.

One diathermy machine for medical and surgical use.

One low frequency machine arranged for galvanic [3] and sinusoidal currents.

One ultraviolet generator (mercury vapor, carbon arc or mercury glow).

One whirlpool bath.[3]

Apparatus for exercising various joints: shoulder wheel,[3] exercise steps,[3] shoulder abduction ladder, Kanavel table,[3] overhead sling and pulley for bed exercises, adjustable stall bars[3] and posture mirror.

3. Directions for making these units may be secured from the Secretary of the Council on Physical Therapy, 535 North Dearborn Street, Chicago.

In addition, if there are many neurologic cases to be treated, it is important to have a faradic coil to aid in muscle and nerve tests.[3] A Hubbard tank[8] is utilized for giving underwater exercises to children with infantile paralysis, congenital dislocation of the hip, tendon transplants and similar conditions in which it is important to restore muscle function without putting too great a strain on weak muscles. With the foregoing equipment, one technician can treat from sixteen to twenty patients a day. In the larger general hospital it will be useful to have a larger personnel and more complete equipment, including additional units of the foregoing types. Naturally this depends on the particular hospital but the list is a tentative suggestion.

Interference with communication by the stray energy radiated through space by diathermy, x-ray and other electrical apparatus has been decreed a nuisance in some localities. If a new building is being erected to house the department, it might be advisable to screen the treatment rooms or even the entire department by suitable conducting material well grounded. Even when a section of an established hospital is turned over to the physical therapy department, conditions may warrant the screening of the room in which equipment is used. In many instances the good will of the local radio user, thus gained, will more than pay for the additional outlay of expense.

Hydrotherapy equipment is used more frequently in institutions for nervous and mental diseases than in general hospitals. These institutions find this a most important physical measure in treating psychoses and psychoneuroses. Equipment of the following nature is used:

Continuous (tub) baths.

Douches and sprays (providing hot and cold water in jet or spray form).

Showers, cabinet and overhead variety.

Sitz baths.

Tables, rubber sheets, blankets (for giving wet packs).

Elaborate hydrotherapy equipment is seldom successful in general hospitals. In smaller hospitals one hydrotherapy room may be utilized for all forms of treatments. If more room is available two rooms are advisable, one for men and one for women.

The most important equipment for a general hospital concentrating in orthopedic work is one of three types of tanks designed for underwater exercises: (1) A large pool where the technician may work in water with the patient; (2) a pool from 3½ to 4½ feet deep, 8 by 15 feet in external dimensions, where the patient may walk while the technician follows around outside the pool, and (3) a Hubbard tank, where the patient can exercise only in a recumbent position. General hospitals dealing with a preponderance of traumatic cases will concentrate on equipment such as the following:

Bakers and infra-red or luminous heaters.

High frequency units.

Whirlpool baths (one for arm and one for leg cases).

Faradic and galvanic apparatus.

Exercise apparatus for muscle reeducation: (A complete set will include types of appliances for exercising each joint of the body, so that graded exercises can be given for any part.)

Equipment for an occupational therapy (curative) workshop.

If fever treatments are to be given, ample space should be set aside. This is needed for special equipment such as the heating unit and cabinet or other devices used for elevating and maintaining temperatures, an electrical thermometer, oxygen and carbon dioxide tanks, basins, extra blankets, towels, dry sheets, and a table. In addition, it is important that there be room enough for the technician to get around quickly in case of an emergency requiring rapid removal of the patient from the heat-maintaining equipment. To reduce the humidity in the room, good ventilation is essential. The Council on Physical Medicine has adopted specifications for fever apparatus and these should be consulted before acquiring equipment.

A final but a most essential consideration lies in keeping records of the cases treated. Without a carefully worked out recording system, the department cannot cooperate with the other divisions of the hospital. Records indicate the value of the treatment both to the patient and to the staff. They enable the director to keep the stream of patients moving, weeding out those who show no improvement. At the same time they point to the progress and growth or stagnation of the department itself.

In conclusion, it is emphasized that 90 per cent of the physical therapy in a general hospital can be done with the simplest physical agents: heat, massage and exercise. The most important factors in a hospital physical therapy department are competent medical direction and efficient physical therapy technicians.[4]

4. Additional references: To 1932: Coulter, J. S.: Principles and Practice of Physical Therapy. Hagerstown, W. E. Prior Company, 1934, vol. 3, pp. 1-48. To 1937: Krusen, F. H.: Physical Therapy in the Hospital, Hospitals **11**: 54 (Aug.) 1937.

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